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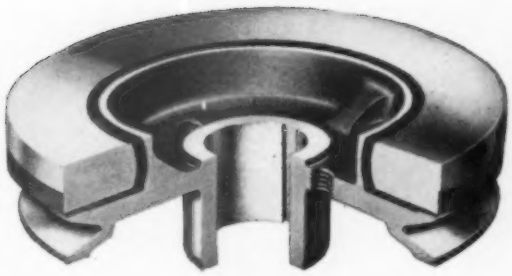

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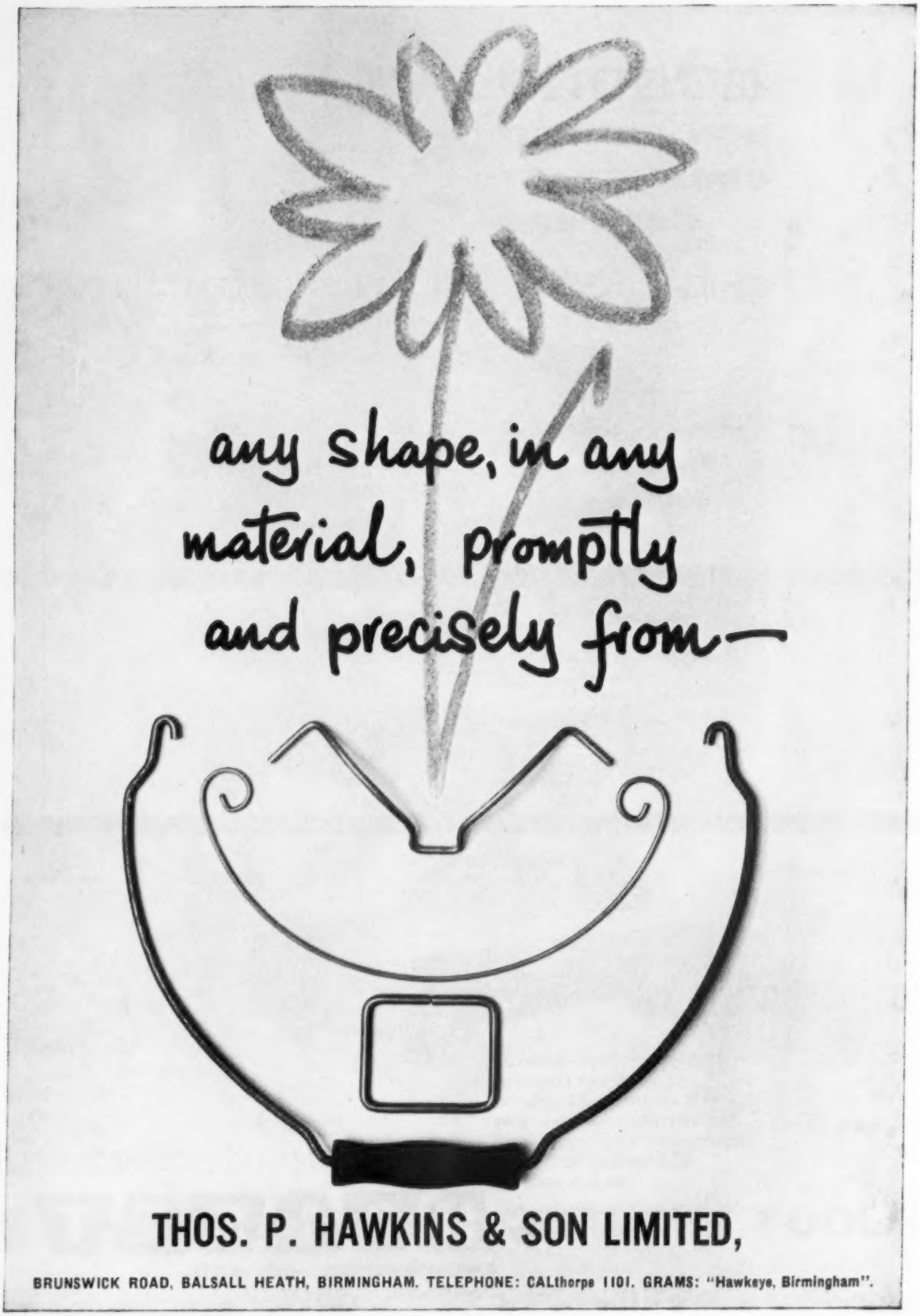
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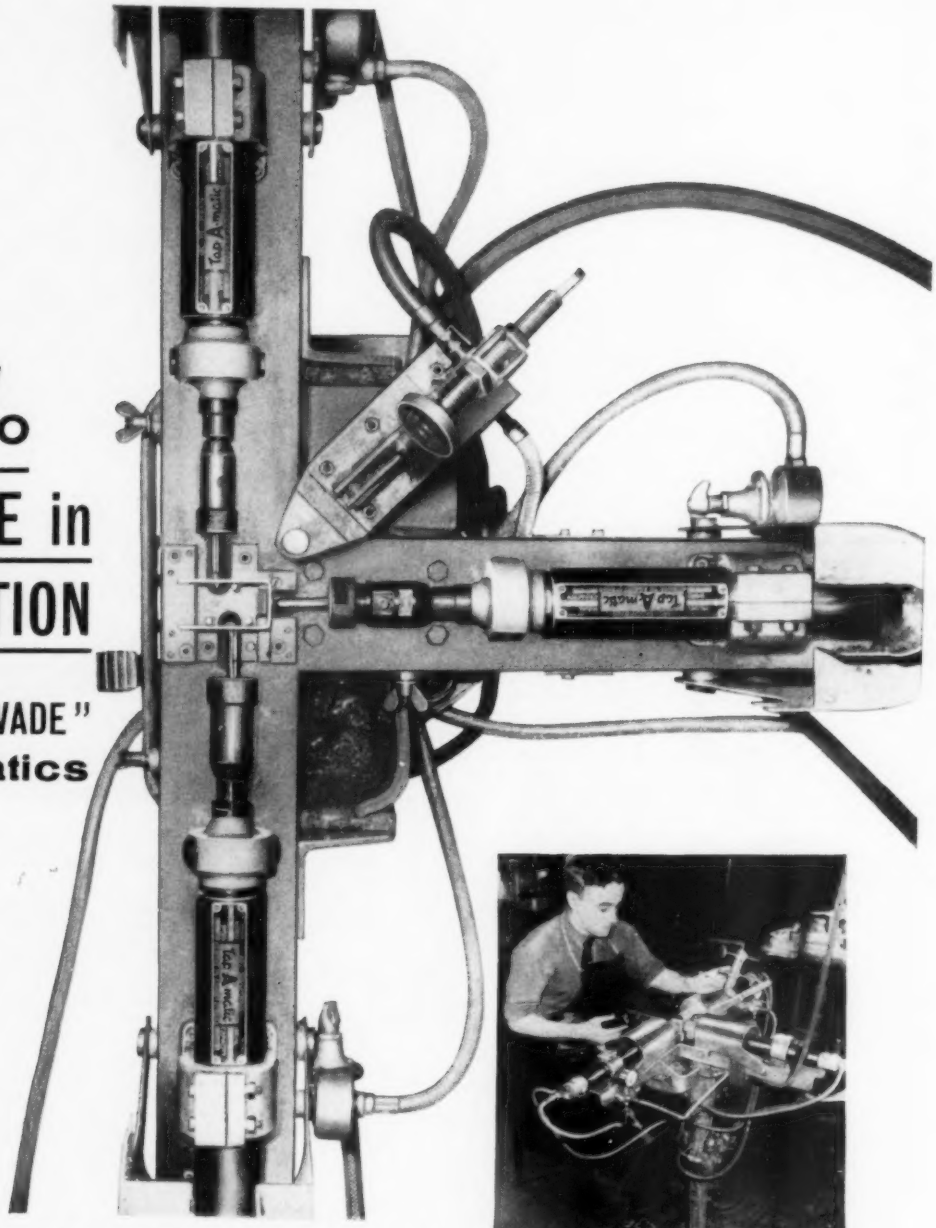

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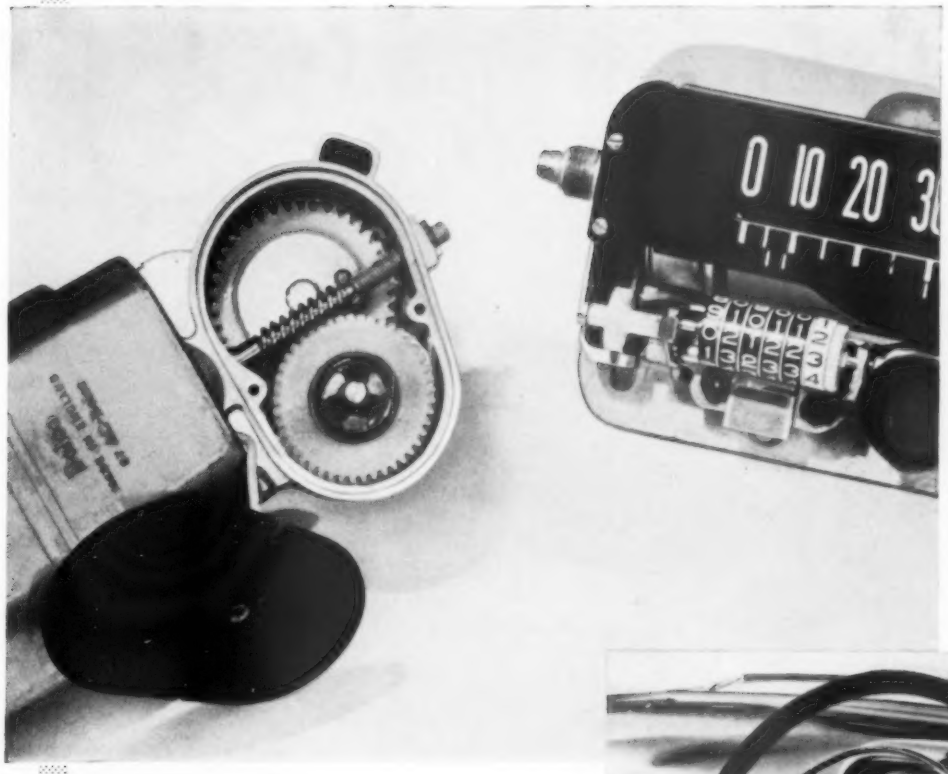
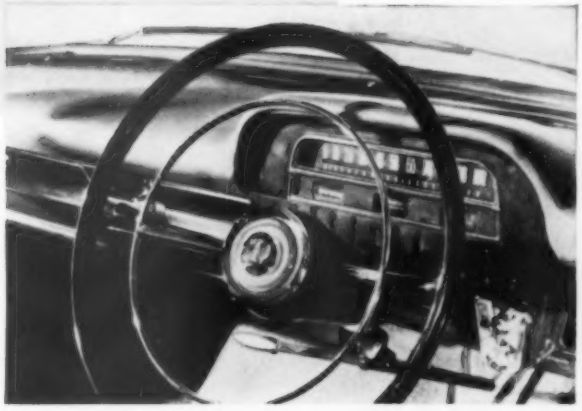


AC combined instrument panel and Delco windscreen wiper motor, showing gear wheels moulded from 'Maranyl' I.C.I. nylon by Messrs. Punfield and Barstow (Mouldings) Ltd., Basil Works, Westmoreland Road, London N.W.9. The instrument panel is fitted to Vauxhall Cresta and Velox cars and the windscreen wiper motor to the Bedford TK Truck. Both units are made by AC-Delco Division of General Motors Ltd., Dunstable.



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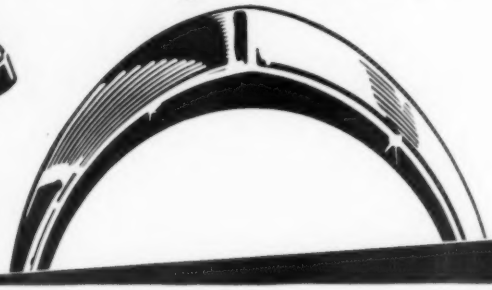

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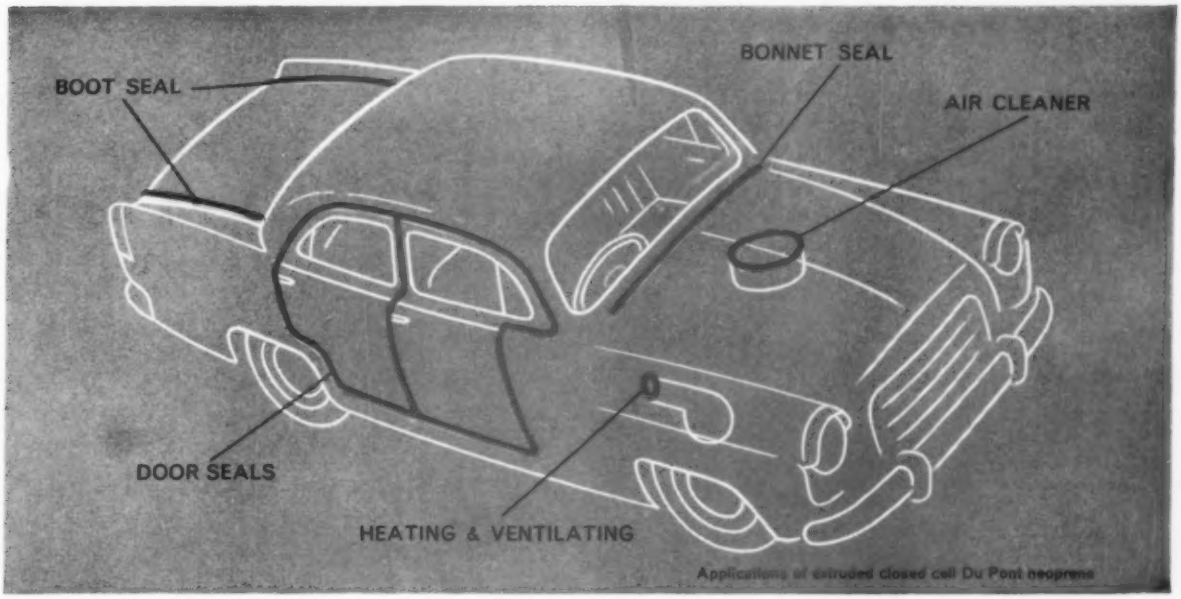
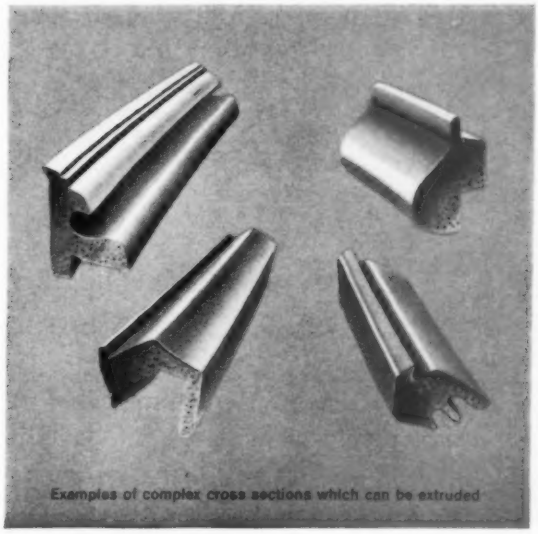


Applications of extruded closed cell Du Pont neoprene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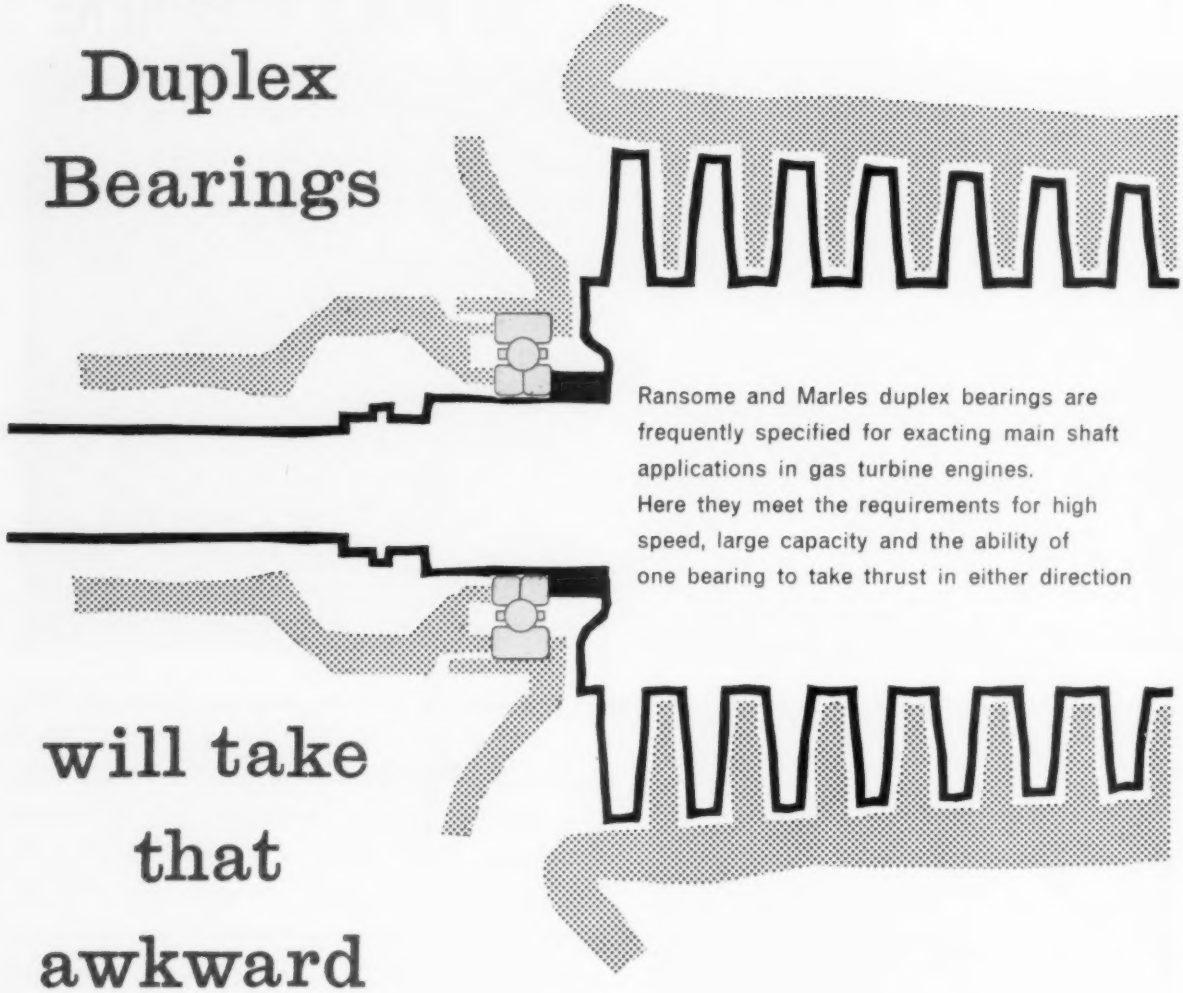

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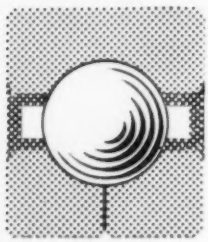

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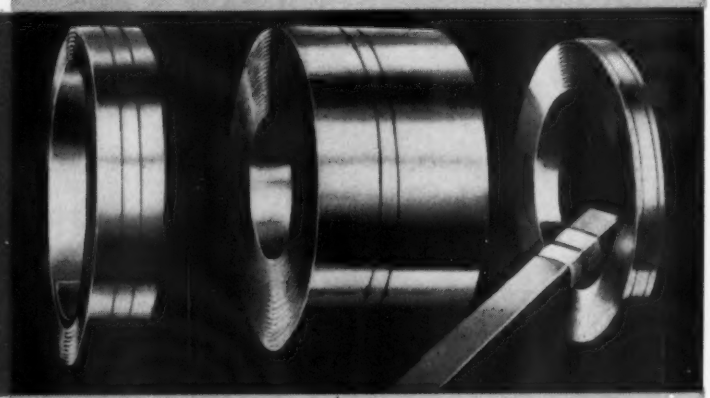

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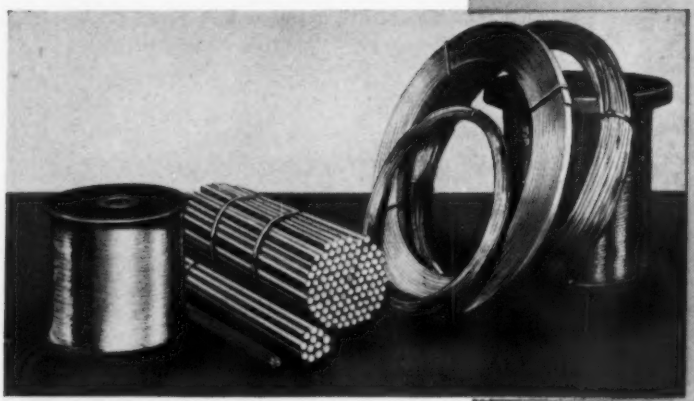

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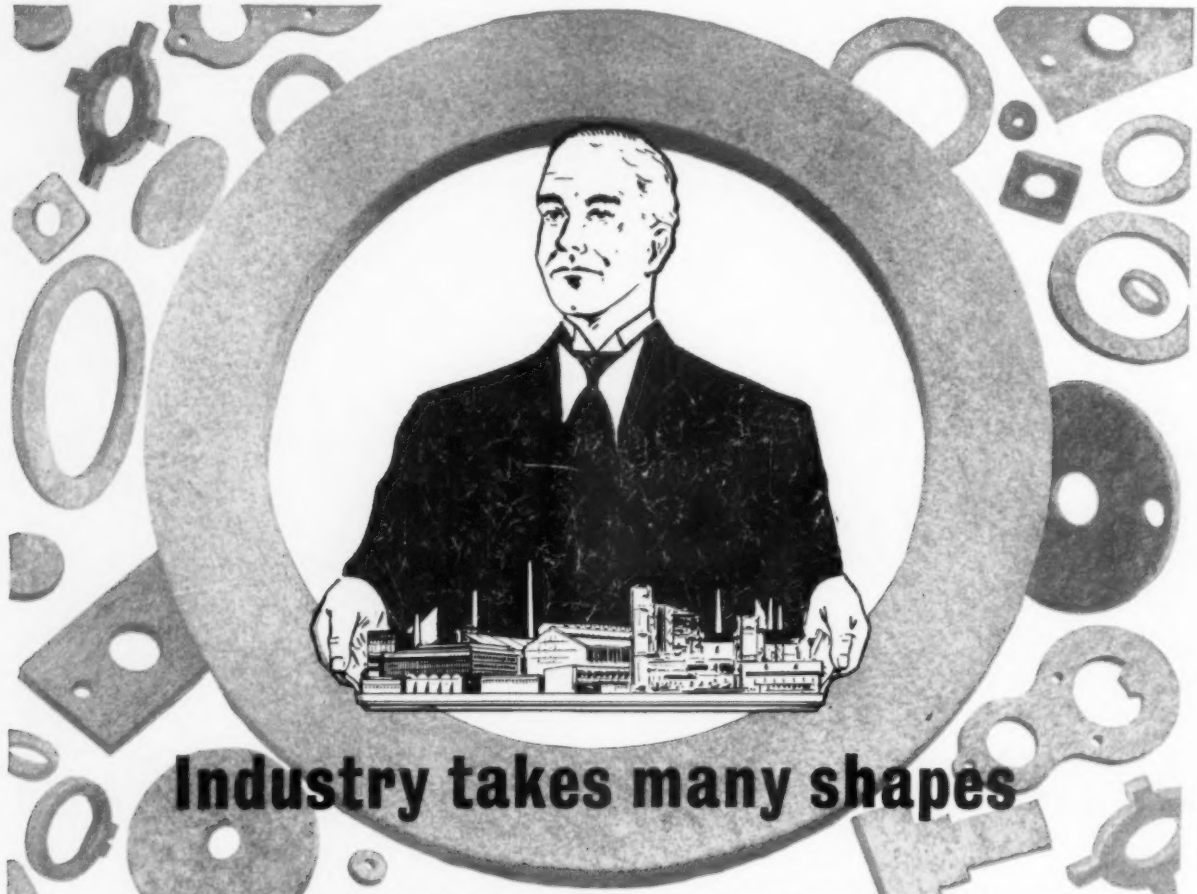

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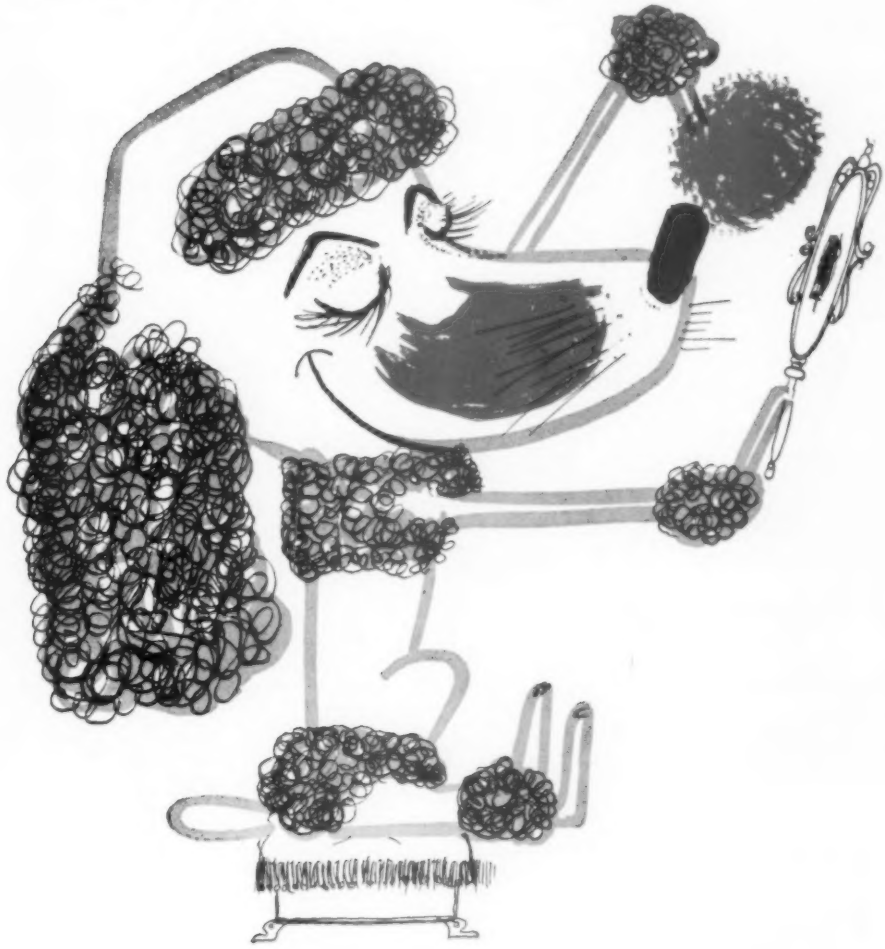

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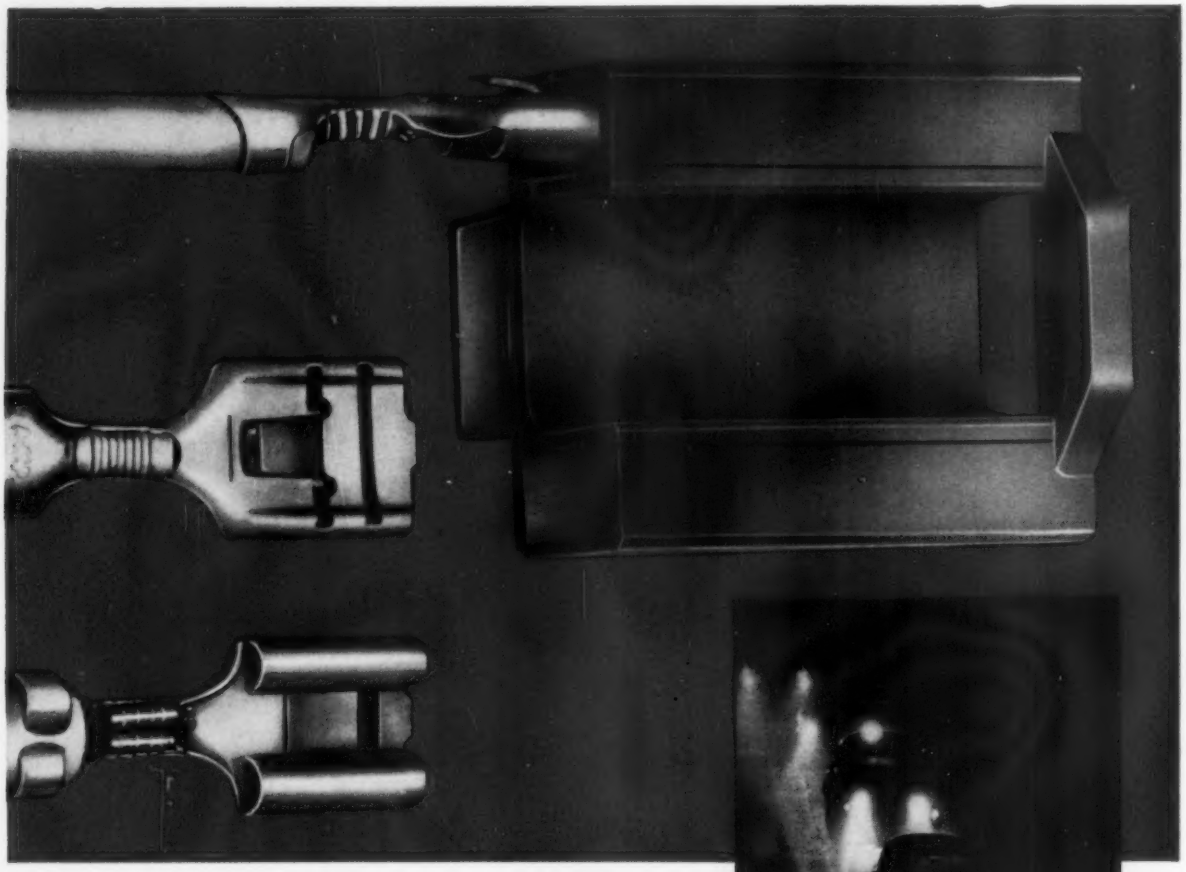

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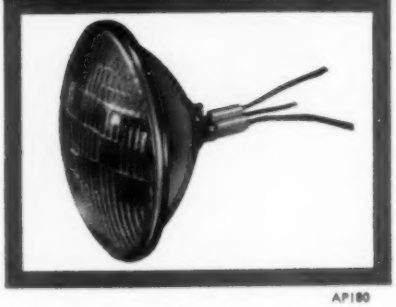

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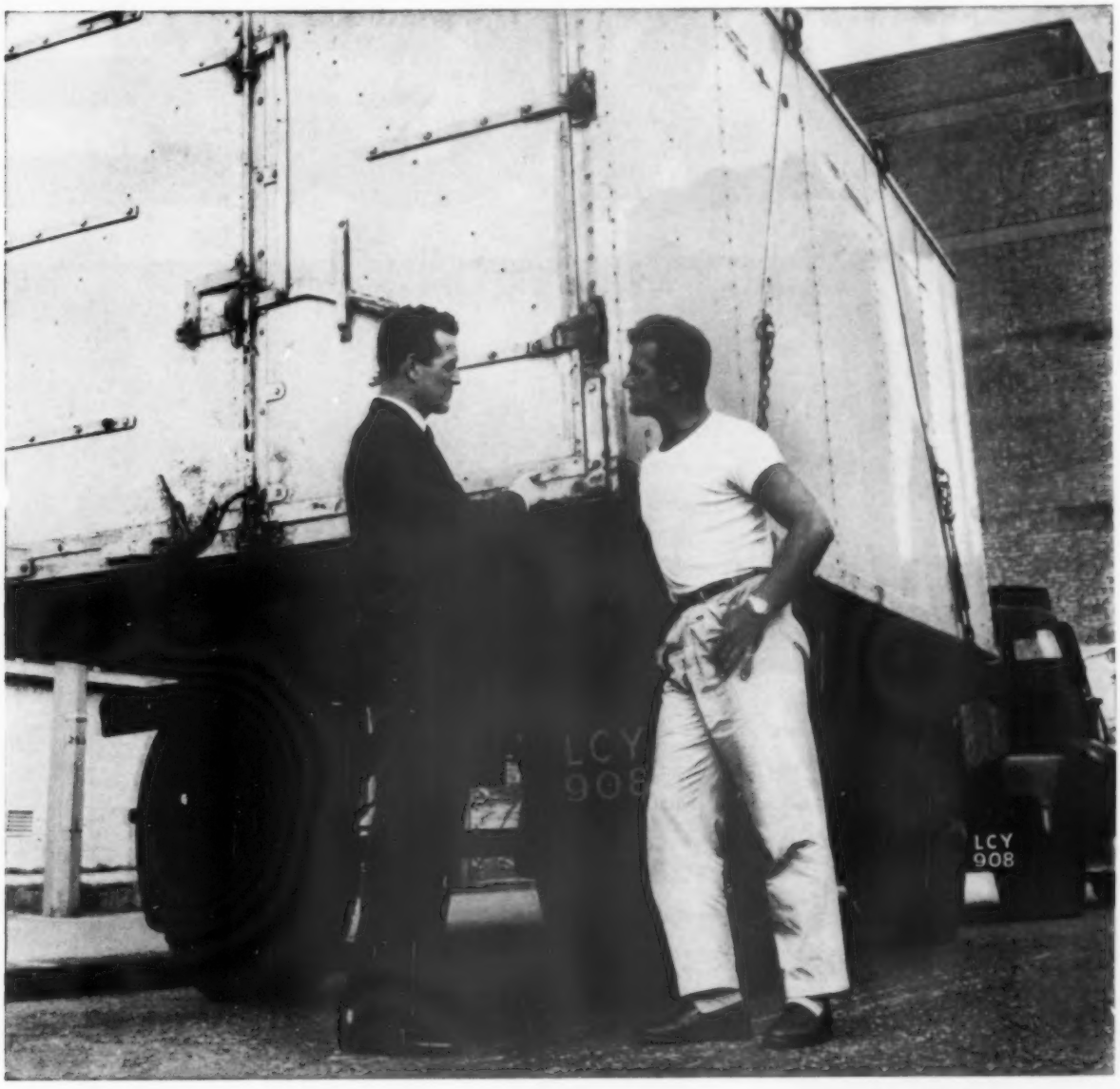

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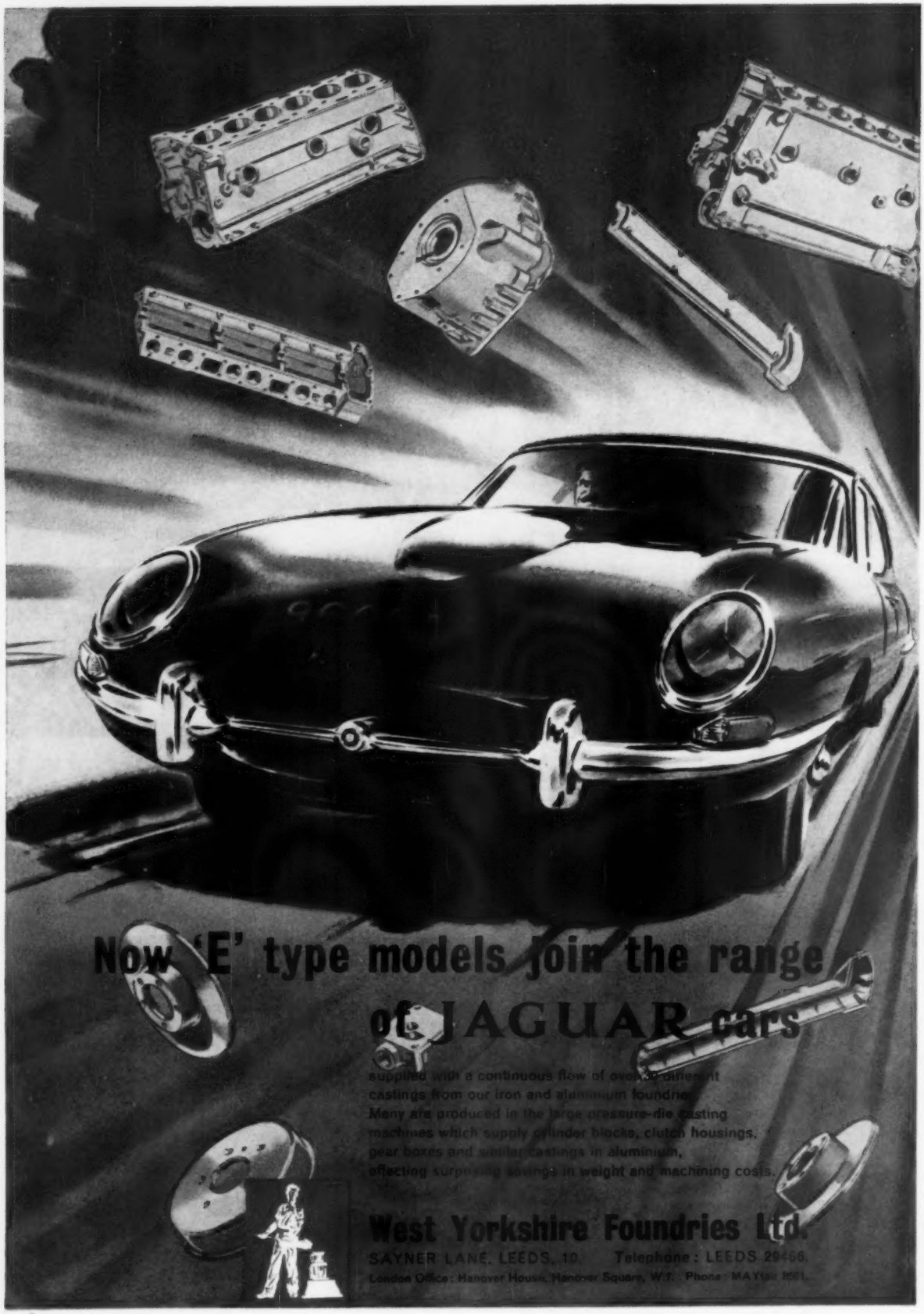
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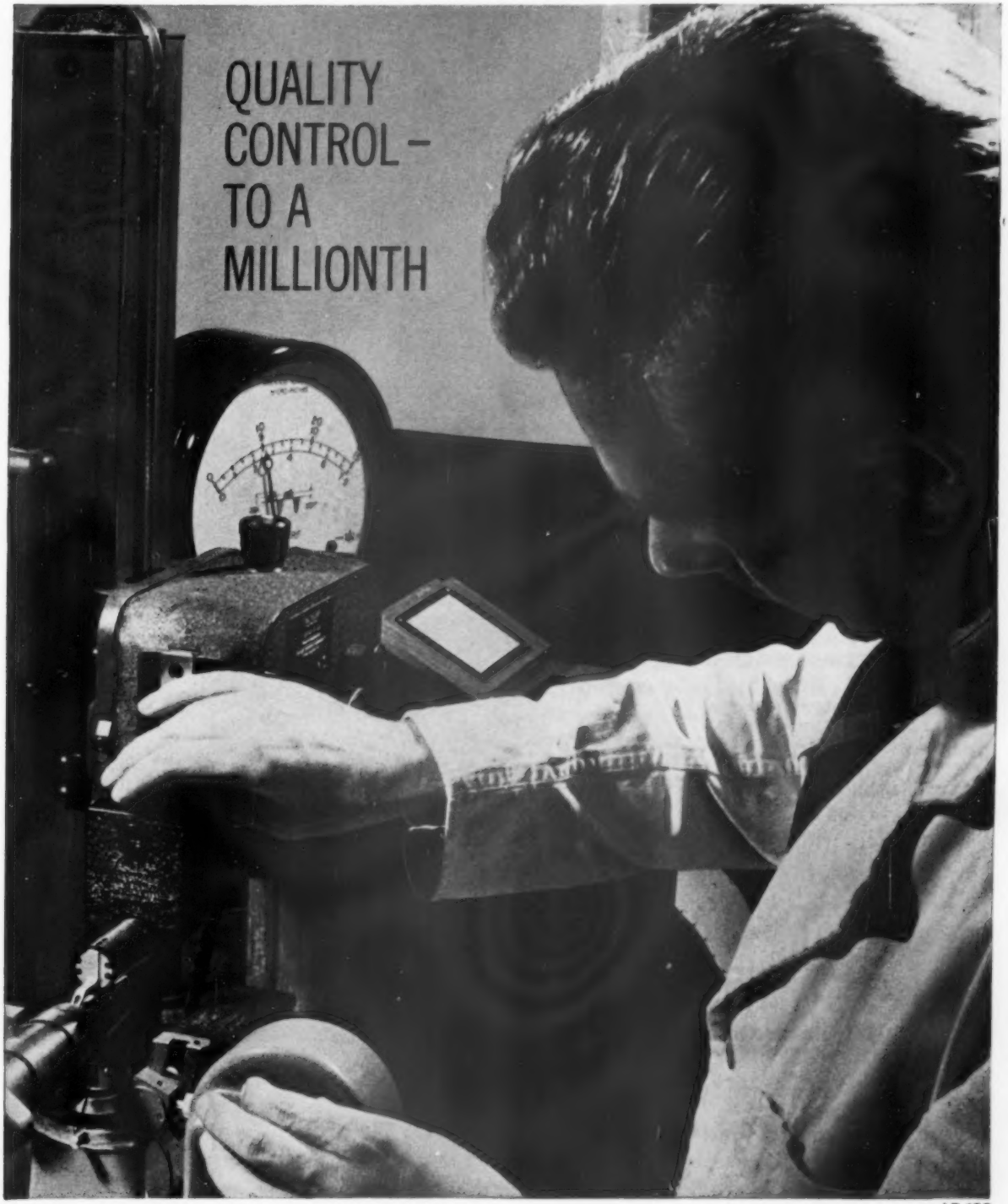

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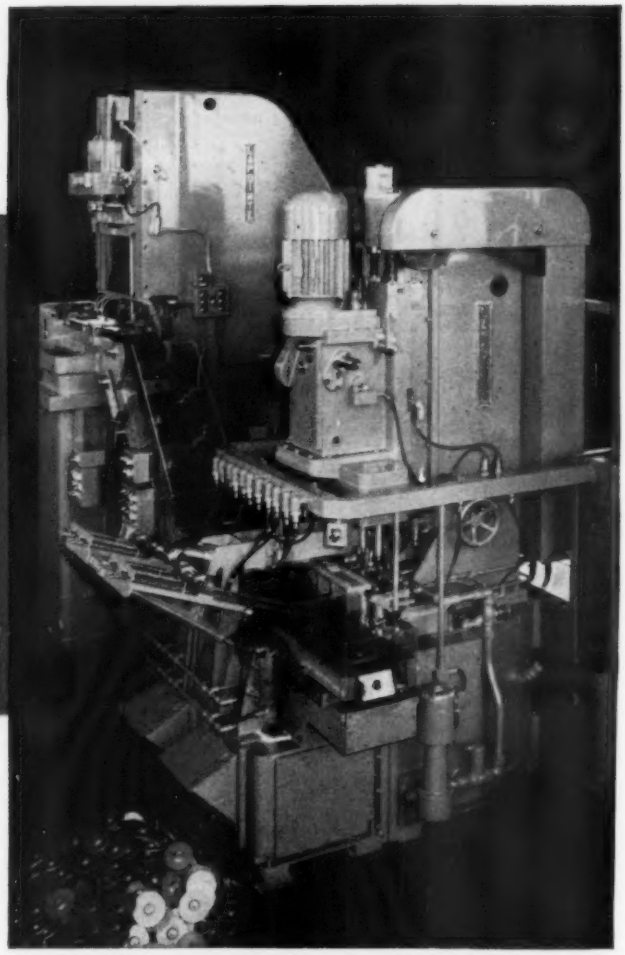

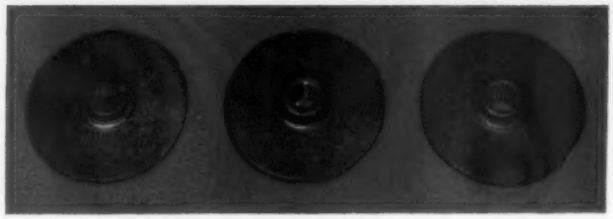

A feature of the fast-moving Ford production line is the transfer drilling and broaching of clutch plates on the new Anglia. Lapointe engineered from start to finish, the machine set-up gives one-operator control with automatic feed and delivery. Sixteen components can be loaded at one time at the drilling station, and the cycle time is four complete components every 78 seconds. Here, as elsewhere, Lapointe know-how begins at the design stage. Their engineering skill is contributing to the high output demands of many modern industries.

LAPOINTE STATISTICS

Drilling – Standard V2 Broaching Machines.
Pulling Capacity 20,000 lb.
Broaching Speed Variable between 5 - 25/ft min

come to LAPOINTE for better broaching

British Made

The Lapointe Machine Tool Co. Ltd

Otterspool Watford By-Pass Watford Herts
Watford 31711 (4 lines) Cables: Lapointe Watford
Subsidiary: Lennie & Thorn Limited Bracknell Berkshire
also The Lapointe Machine Tool Company Hudson Mass. USA

The "Margam Abbey"—built for the Port Talbot Pilotage Authority by Richard Ironworks Ltd., in which Cor-Ten was used extensively. Photograph by courtesy of the Port Talbot Pilotage Authority

COR-TEN GOES DOWN TO THE SEA IN SHIPS

At sea as well as ashore new uses are constantly being found for SCW Cor-Ten. It was used extensively in the construction of this vessel for the Port Talbot Pilotage Authority.

The Main Deck and Bulwark Plating
Shell Plating and Anchor Recess
Floors and Engine Seating
Chain Locker
Fresh Water Tank
Bulkhead Bottom Plating
Rudder Side Plates

—were made entirely from Cor-Ten. A typical example of the growing use of Cor-Ten in marine construction, and in other fields where high yield strength, together with outstanding resistance to corrosion, is vital.

COR-TEN IS TOUGHER

Weight for weight, the yield strength of SCW Cor-Ten is 50% higher than ordinary mild steel.

Alternatively—
Strength for strength, a saving of 1/3 of the weight is possible.

4–6 times more resistant to atmospheric corrosion. Highly resistant to abrasion and fatigue.

COR-TEN SAVES MONEY

Initial costs are spread over a longer service life.

Maintenance costs are reduced.

Operating costs are lowered—in transport, payloads are bigger because of reduction in tare weight.

Please write to us at the address below for further information or for technical assistance in the application of SCW Cor-Ten to your products.

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RAILWAY ROLLING STOCK. AGRICULTURAL AND EARTH-MOVING EQUIPMENT. MINE CARS. POWER STATION INSTALLATIONS. BARGES AND SMALL CRAFT

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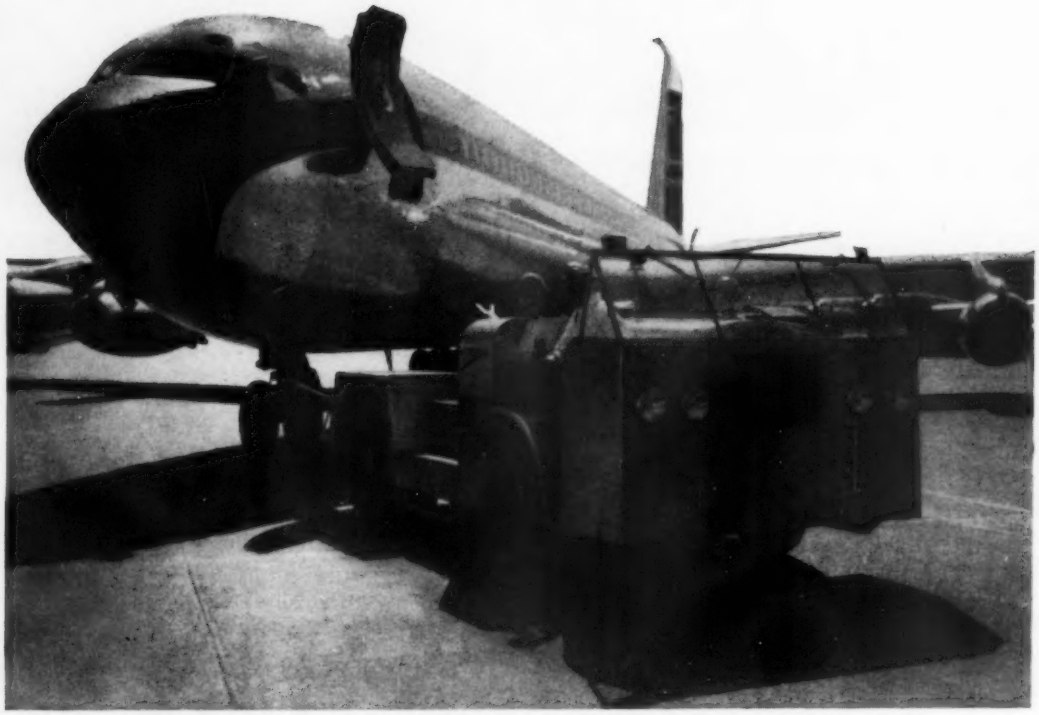
Sales Offices: United Kingdom—Abbey Works, Port Talbot, Glamorgan. Overseas—Margam House, 26 St. James's Sq., London, S.W.1

KIRKSTALL AXLES



Mercury 160L Tractor with Kirkstall Axles towing a Boeing 707.

KIRKSTALL FORGE ENGINEERING LIMITED LEEDS, 5

Telephone: Horsforth 2821

There's something special about this tool...

A Hicycle grinder wire brushing bellows at the works of Munrow & Miller Ltd. Edinburgh.

Hicycle tools are of special interest to you

Here's why

- **INCREASED PRODUCTION** A constant speed is maintained irrespective of load.
- **REDUCED WEIGHT** High sustained motor speed gives increased power to weight ratio, and so makes for effortless operation.
- **LESS MAINTENANCE** There are no commutators, brushes or brush gear to maintain, and the squirrel cage rotor cannot burn out.
- **GREATER ECONOMY** A Hicycle tool uses only a fraction of the power of a comparable compressed air tool.
- **MORE SAFETY** The voltage to earth is only 72 volts—safer than tools operating on the usual 200/250 volts.

It's a worker that never flags . . . . it maintains a constant grinding speed, whatever the load. This means far less operator fatigue and much more output per shift—often as much as 50% extra—compared to conventional power tools. Hicycle electric tools are available for most heavy-duty rotary operations, and are hard at work in virtually every industry. The Hicycle catalogue will be gladly sent on request.

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electric production tools by
CONSOLIDATED PNEUMATIC

For a better finish —faster!

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grilles, tread plates,
fascia panels, interior trim, bumpers.

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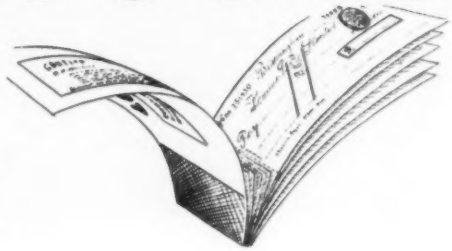
How much wiser to buy a seal that costs you a penny or so more originally, but by its length of life and reliability saves you that penny and pounds besides.

Superfect Seals might cost that penny or so more—and if so there are good reasons. Our continual research into the problems affecting oil sealing, our strict maintenance of quality production, the use of first-class raw materials and exhaustive inspection of the finished product all add up to SuPerfection.

Are you being penny wise only to be pound foolish?
If so you'd better see *us* about it.



SuPERFECT

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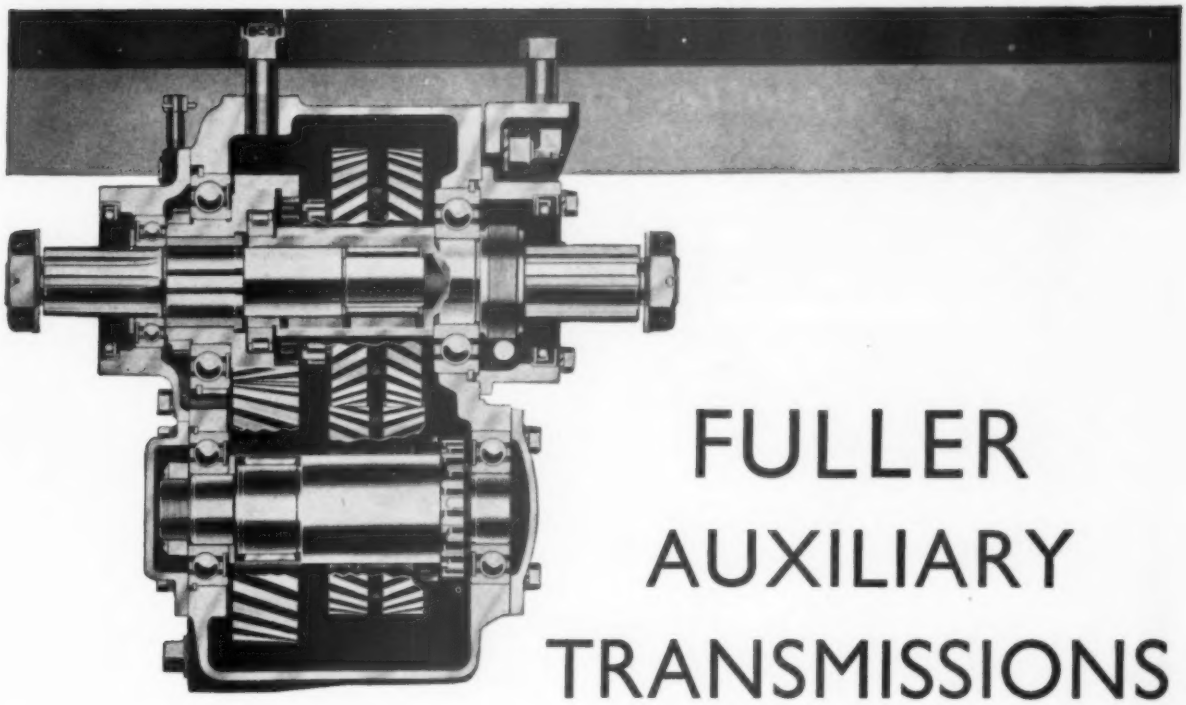

This section of the 2-A-62/2-B-62 two-speed transmission shows the robustness which is characteristic of all Fuller transmissions. Note the generous double-helical constant-mesh gears and the parallel-roller spigot bearing.

FULLER AUXILIARY TRANSMISSIONS

The two-speed box illustrated is suitable for use behind the main gearbox of vehicles having engines of approximately 620 cu. ins. capacity.

This box, and other Fuller auxiliary boxes giving 2, 3 or 4 speeds, enables a manufacturer to meet the demand for specialized heavy transport vehicles while still retaining standard engines and main transmissions.

OTHER FULLER TRANSMISSIONS

Fuller transmissions are also available giving 5, 7, 8, 9, 10 and 15 forward speeds, plus reverses: they include the famous Road-Ranger transmissions which simplify gear-changing and avoid gear-splitting.

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AUTOMOTIVE HOUSE, GREAT PORTLAND STREET, LONDON, W.1
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Sole European Representatives for the Fuller Transmission Division, Eaton Manufacturing Co., U.S.A.

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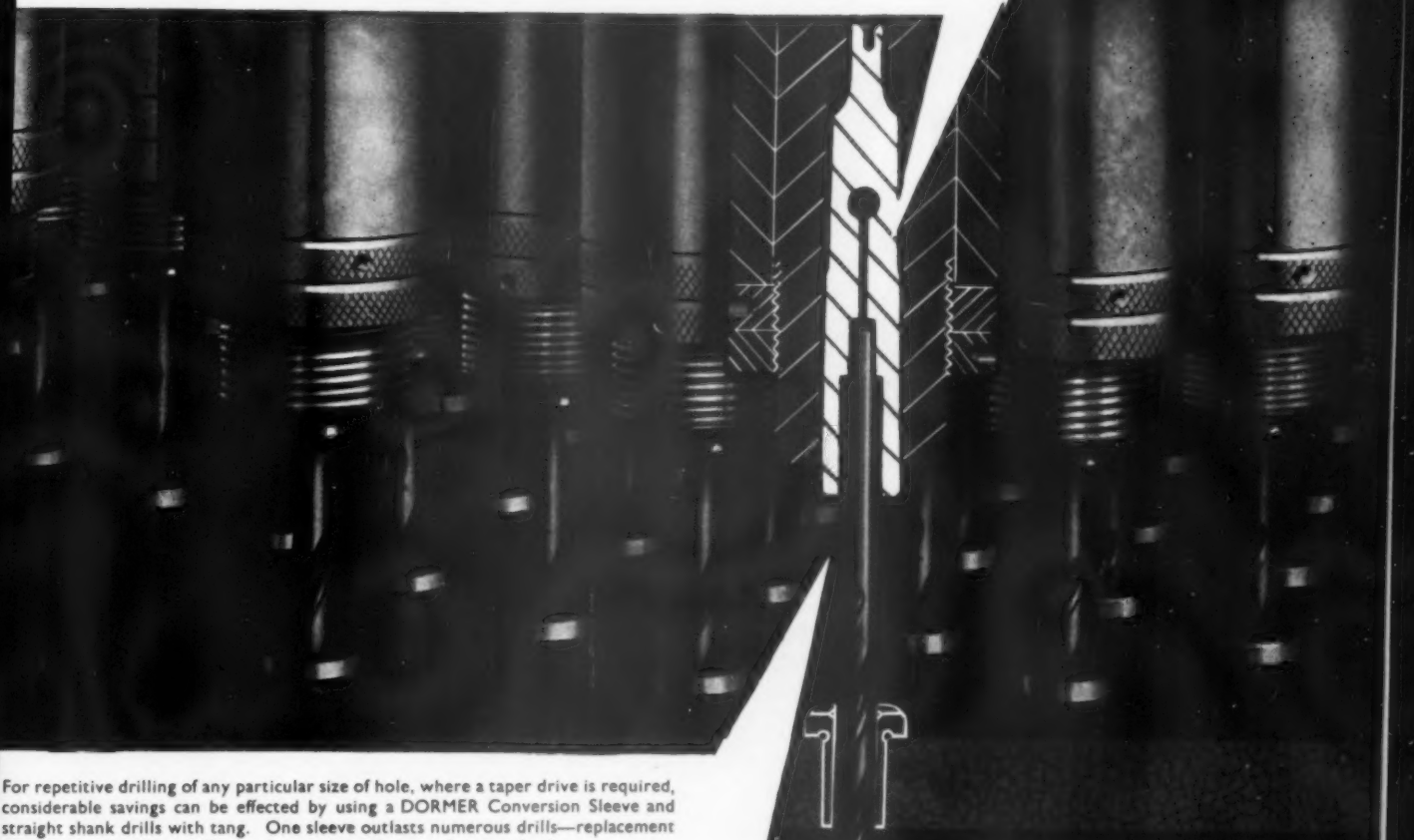
ANOTHER DORMER ECONOMY



For repetitive drilling of any particular size of hole, where a taper drive is required, considerable savings can be effected by using a DORMER Conversion Sleeve and straight shank drills with tang. One sleeve outlasts numerous drills—replacement straight shank jobber drills are cheaper than those with taper shanks.

Additionally this drive permits drilling to much closer centres than with the conventional straight shank drill chucks—more holes can be drilled simultaneously.

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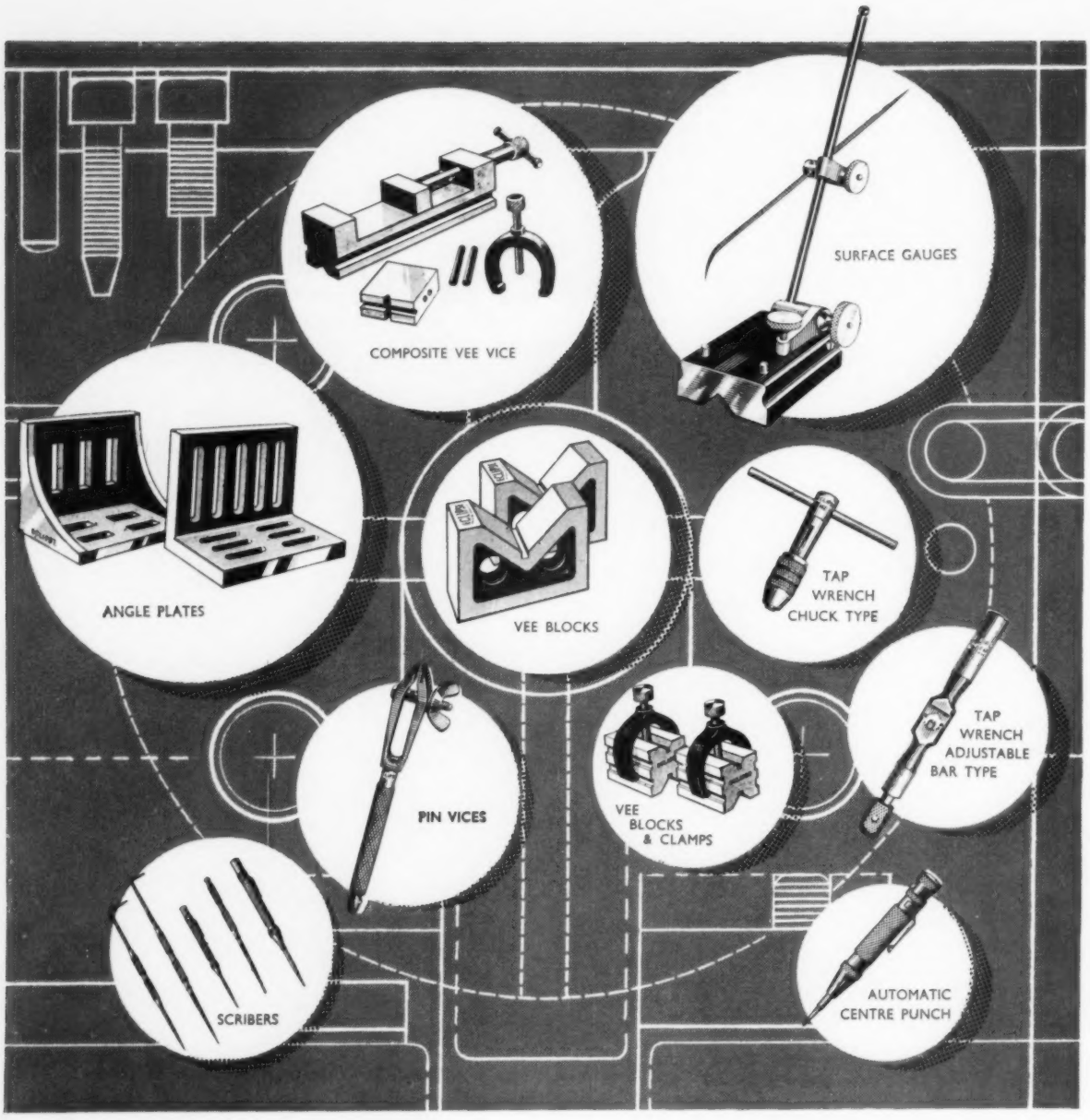
CONVERSION SLEEVES AND TANGED STRAIGHT SHANK DRILLS



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FORD

in the choice of components. The Silentbloc Group take it as a very great compliment that so many of their products are incorporated in this brilliant new model.

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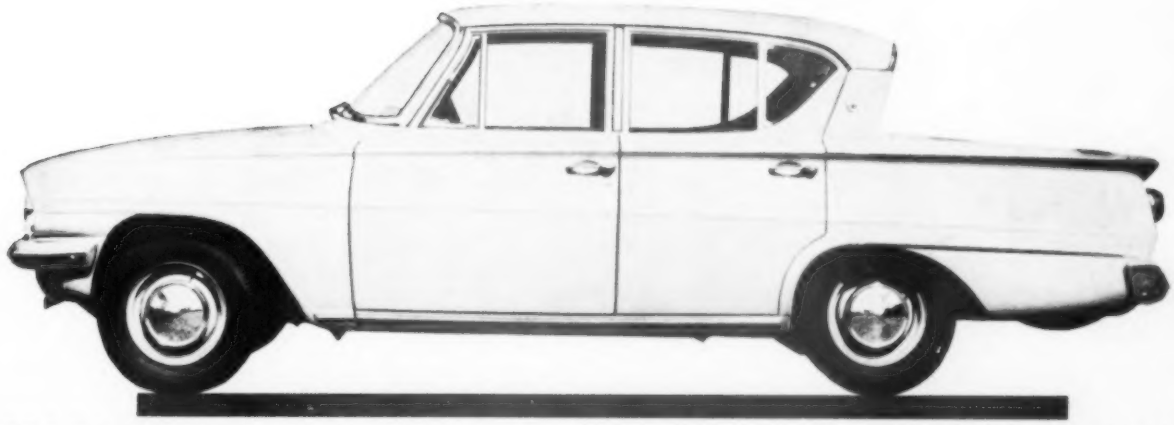

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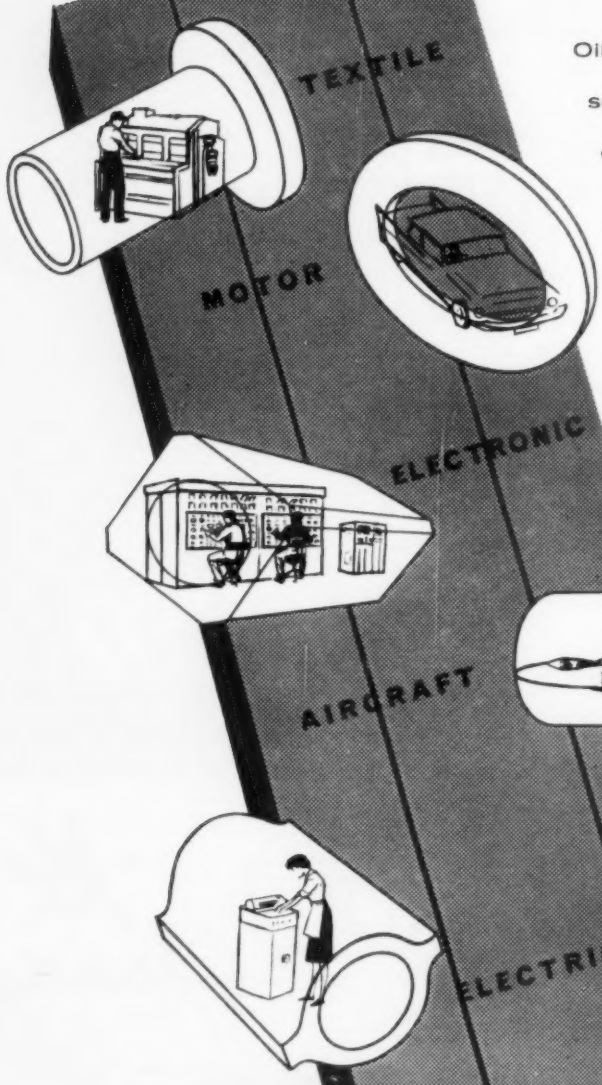

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AND OILITE bearings ensure trouble-free running, reduce maintenance costs.

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P.6158

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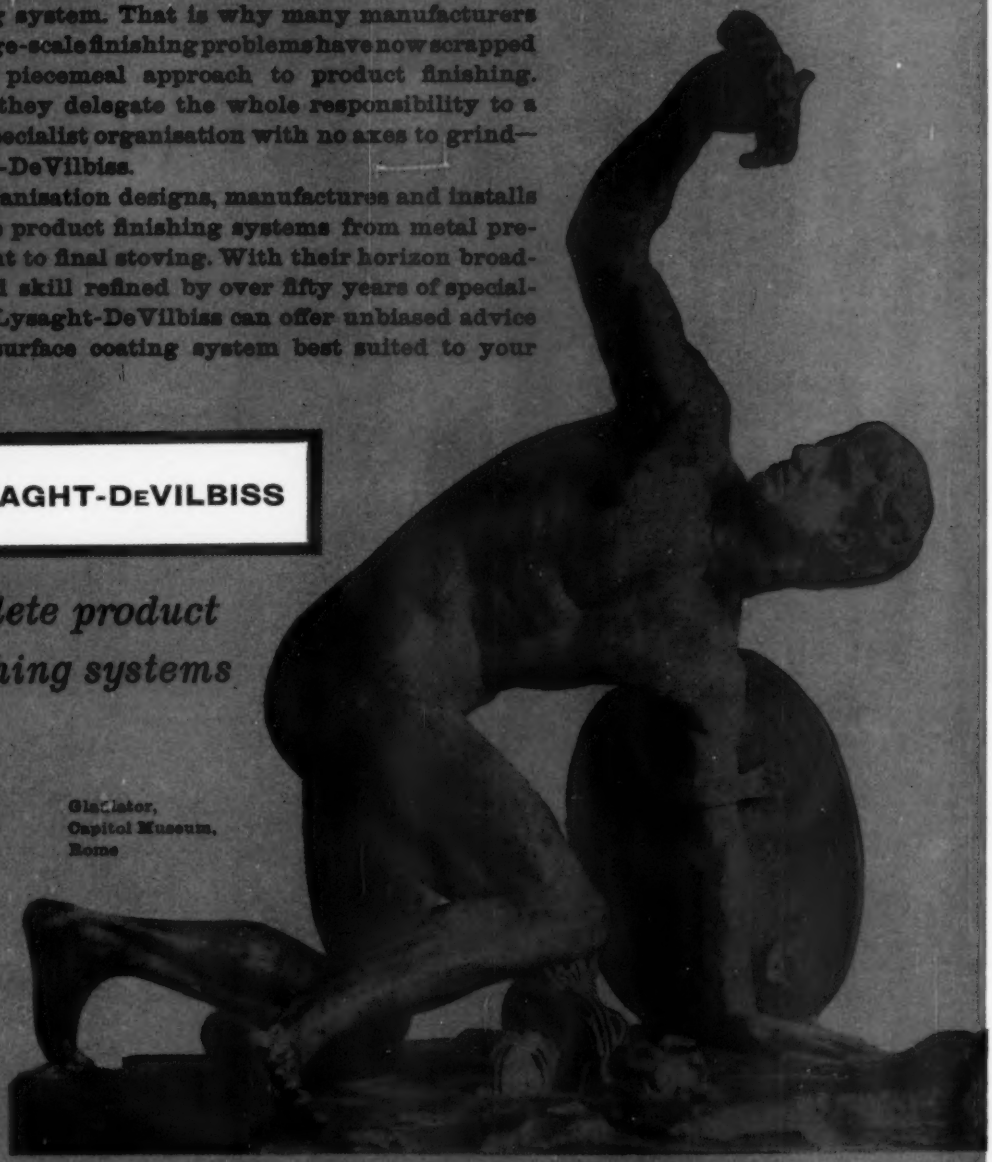
LYSAGHT-DEVILBISS

complete product finishing systems



Gladiator, Capitol Museum, Rome

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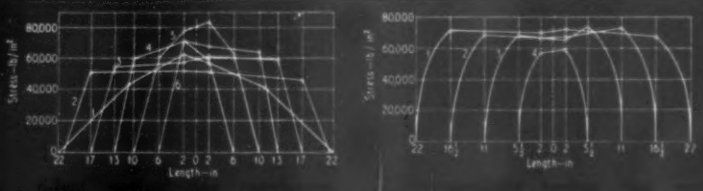
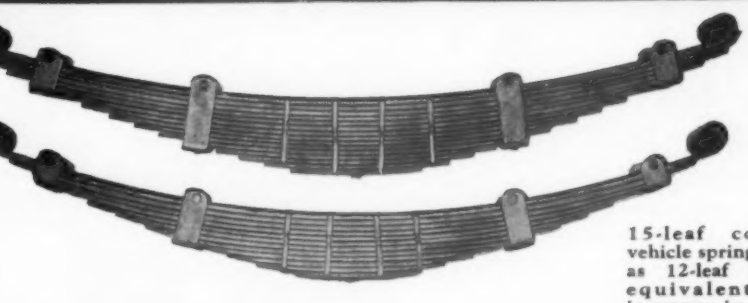
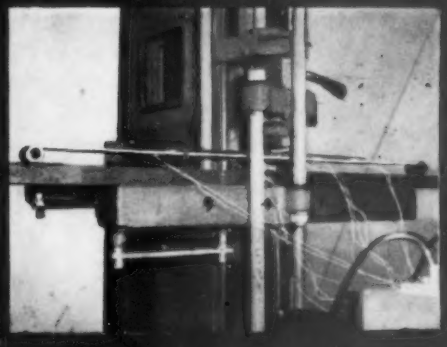
Production spring with 6 leaves redesigned as a 4-leaf Ideal spring.





15-leaf commercial vehicle spring redesigned as 12-leaf Featherlight equivalent without increase in maximum stress.



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IDEAL SPRING
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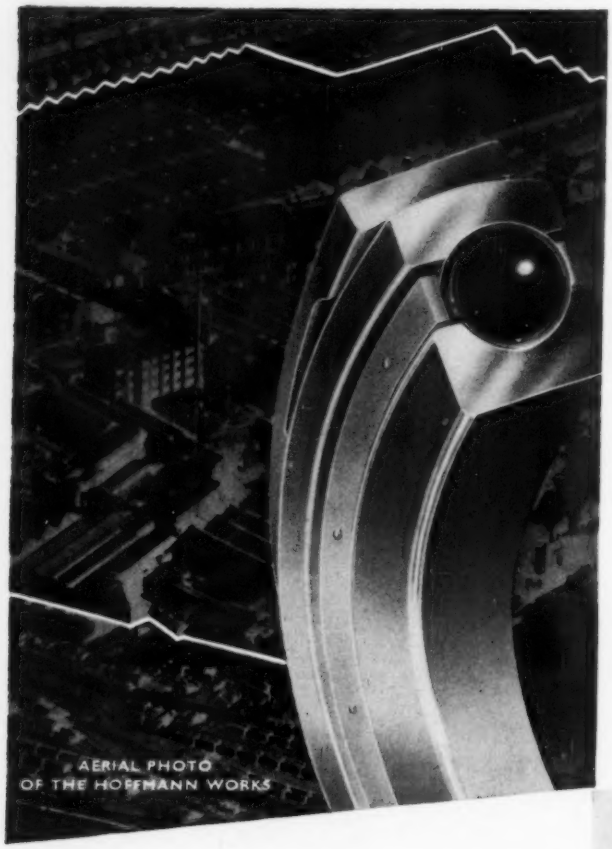

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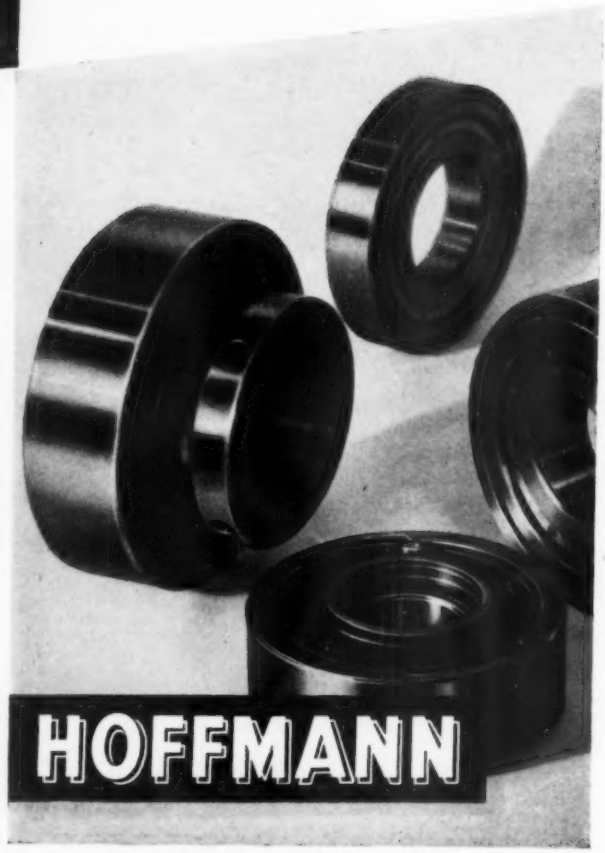

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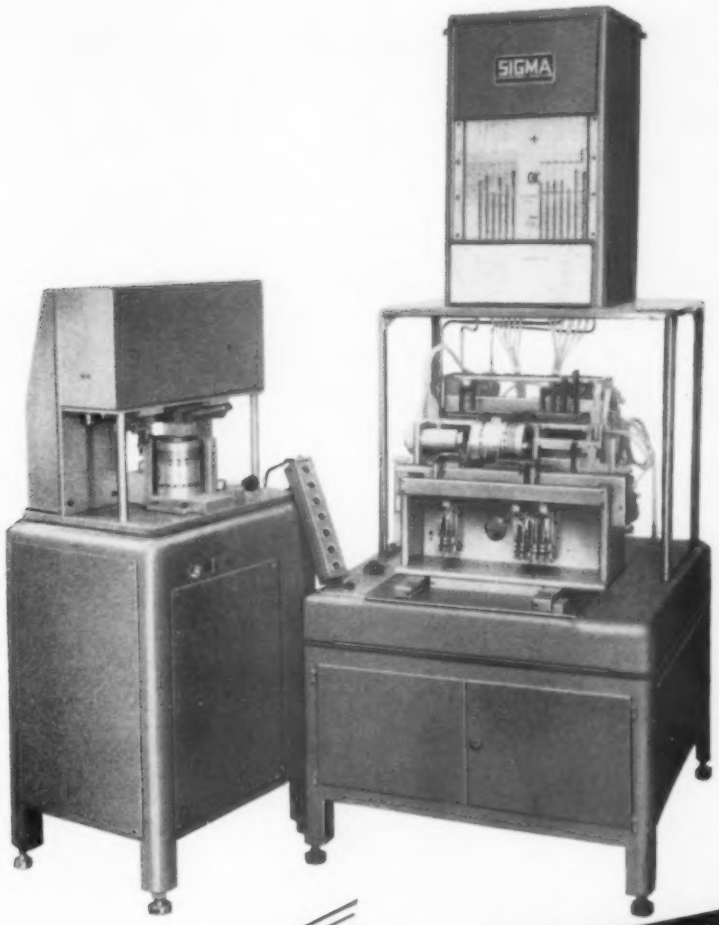

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inspects internal and external diameters and lengths, thickness, radii, tapers, threads, concentricity, squareness, wobble, straightness, profile, relationship and ovality . . . singly or in any combination up to sixty dimensions simultaneously. Component stationary or revolving; both conditions on two-stage machine.

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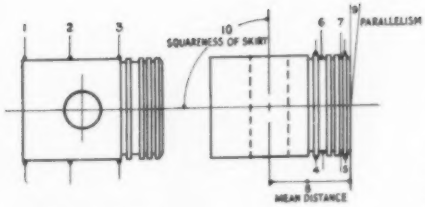

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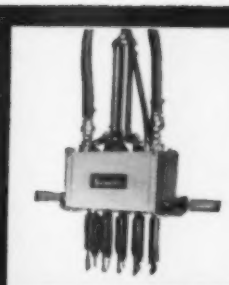
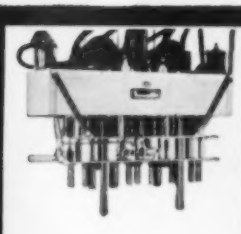


A Desoutter multi-studrunner plants 9 studs into an Austin cylinder block.

CHOUF!

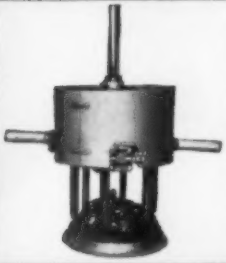


A Desoutter multi-nutrunner fixes 25 nuts on a Ford diesel cylinder head.

CHOUF!

A Triumph Herald sump is put on by a Desoutter 16-spindle multi-nutrunner.

CHOUF!



A Desoutter multi-nutrunner assembles a Vauxhall clutch plate, or tightens the wheel nuts on a Rootes Group car. And so it goes on: the Desoutter CHOUF speeds mass-production, makes sweet music in industrialists' ears. And no wonder—everyone has a taste for that sort of music—and nearly everyone has something to play it on! CHOUF! (on a carburettor)... CHOUF! (or a light fitting)... CHOUF! (or a washing machine)... CHOUF! (or anything else that needs assembling).

DESOUTTER MULTI-NUTRUNNERS · SCREWDRIVERS AND STUDRUNNERS

DESOUTTER BROTHERS LIMITED · THE HYDE · HENDON N.W.9

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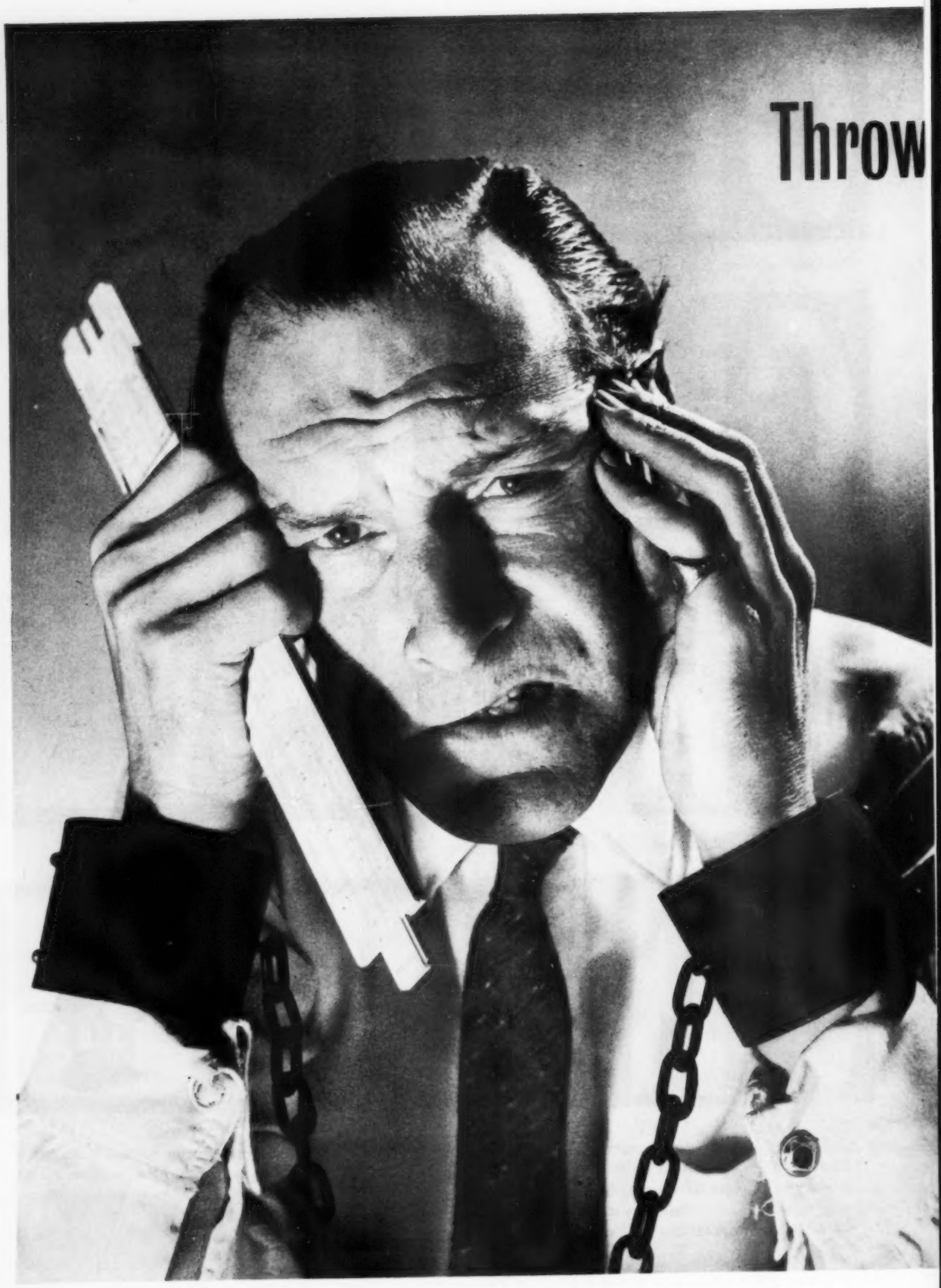
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off those shackles, Mr. Designer!

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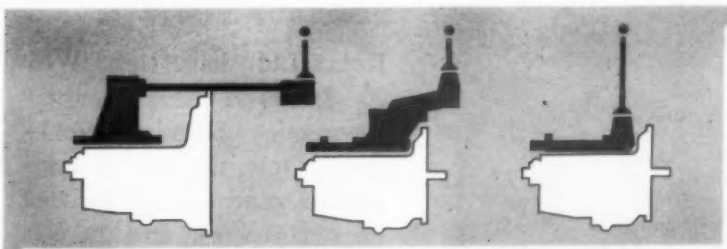
Specify the DB552 5-speed gearbox

THREE CONTROL POSITIONS PLUS PROVED DESIGN!



Forward Control *Semi Forward Control* *Centre Control*

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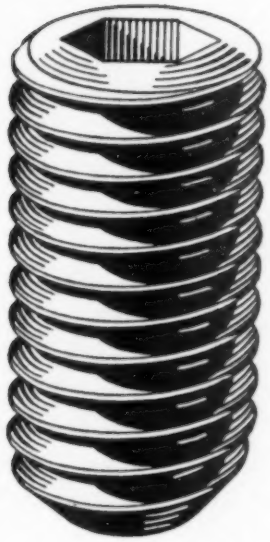

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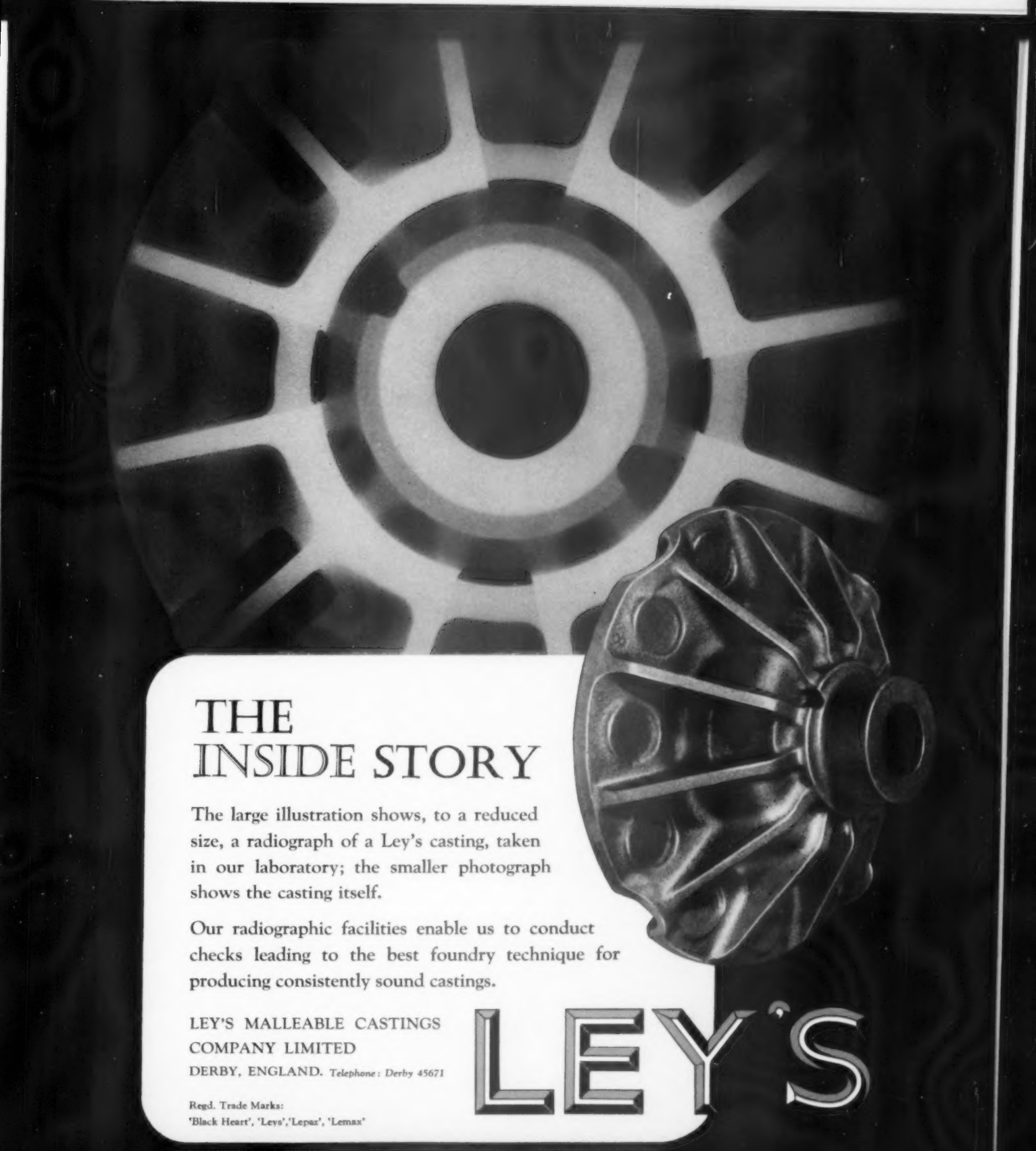

THE INSIDE STORY

The large illustration shows, to a reduced size, a radiograph of a Ley's casting, taken in our laboratory; the smaller photograph shows the casting itself.

Our radiographic facilities enable us to conduct checks leading to the best foundry technique for producing consistently sound castings.

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DERBY, ENGLAND. *Telephone: Derby 45671*

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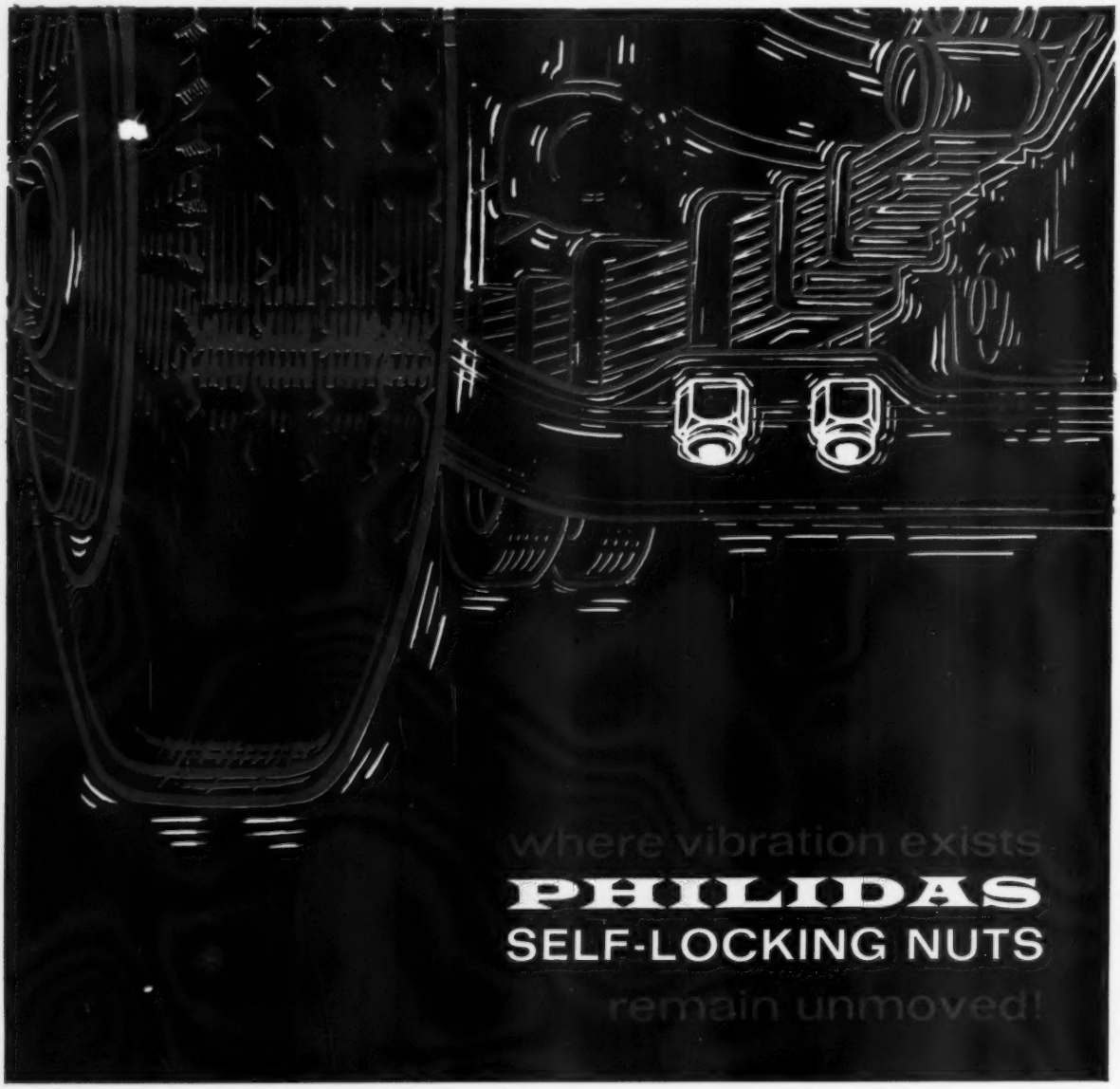

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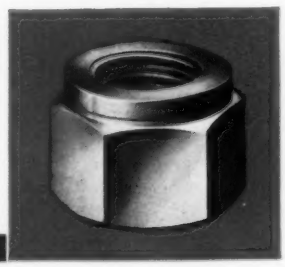

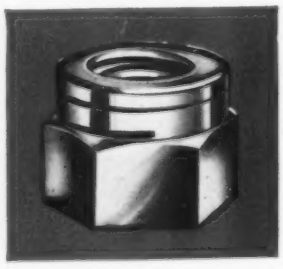

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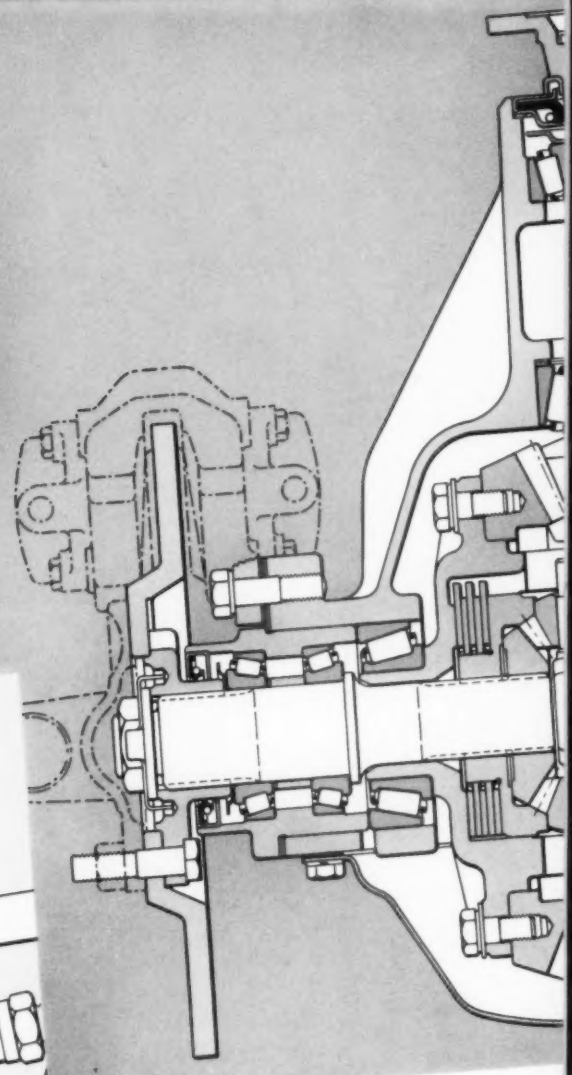
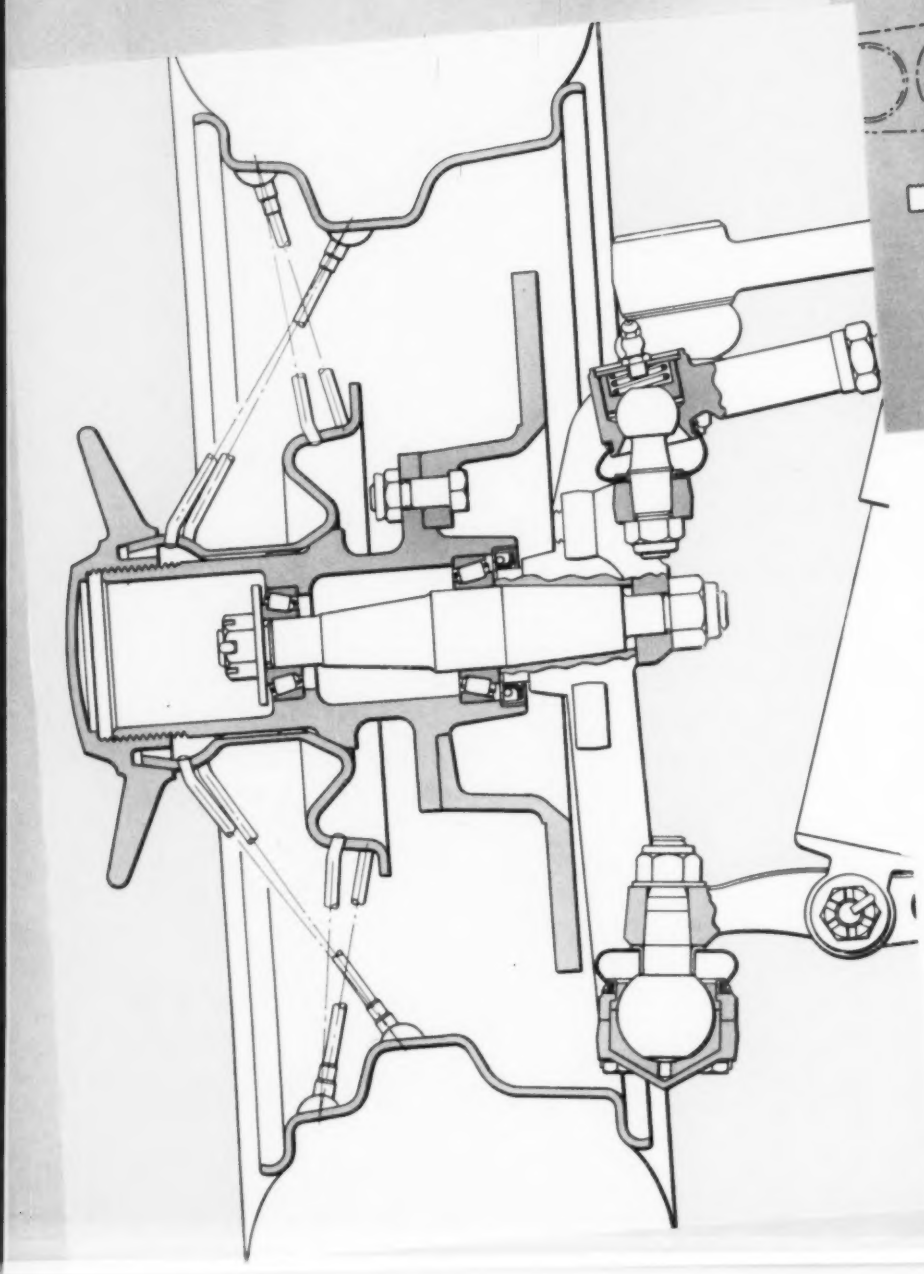
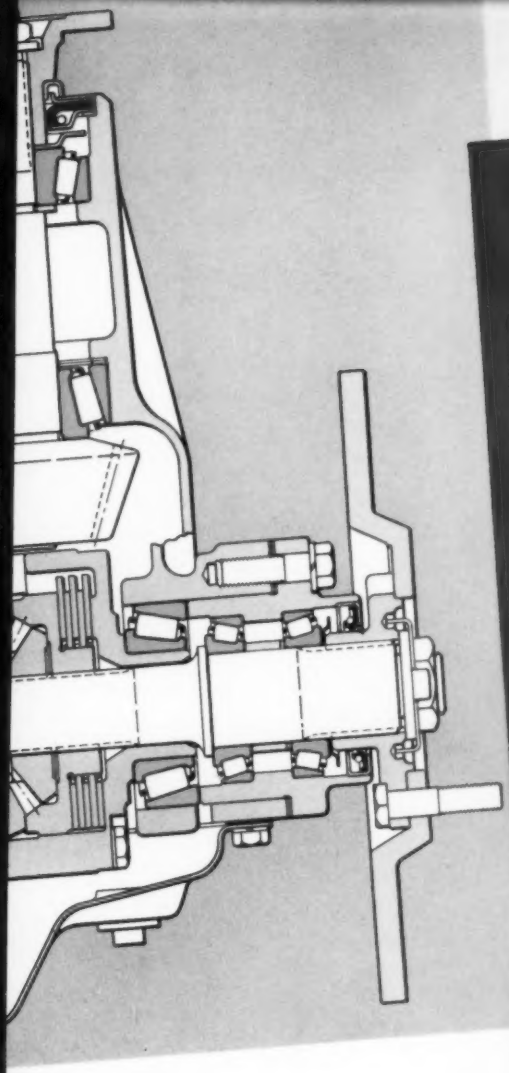


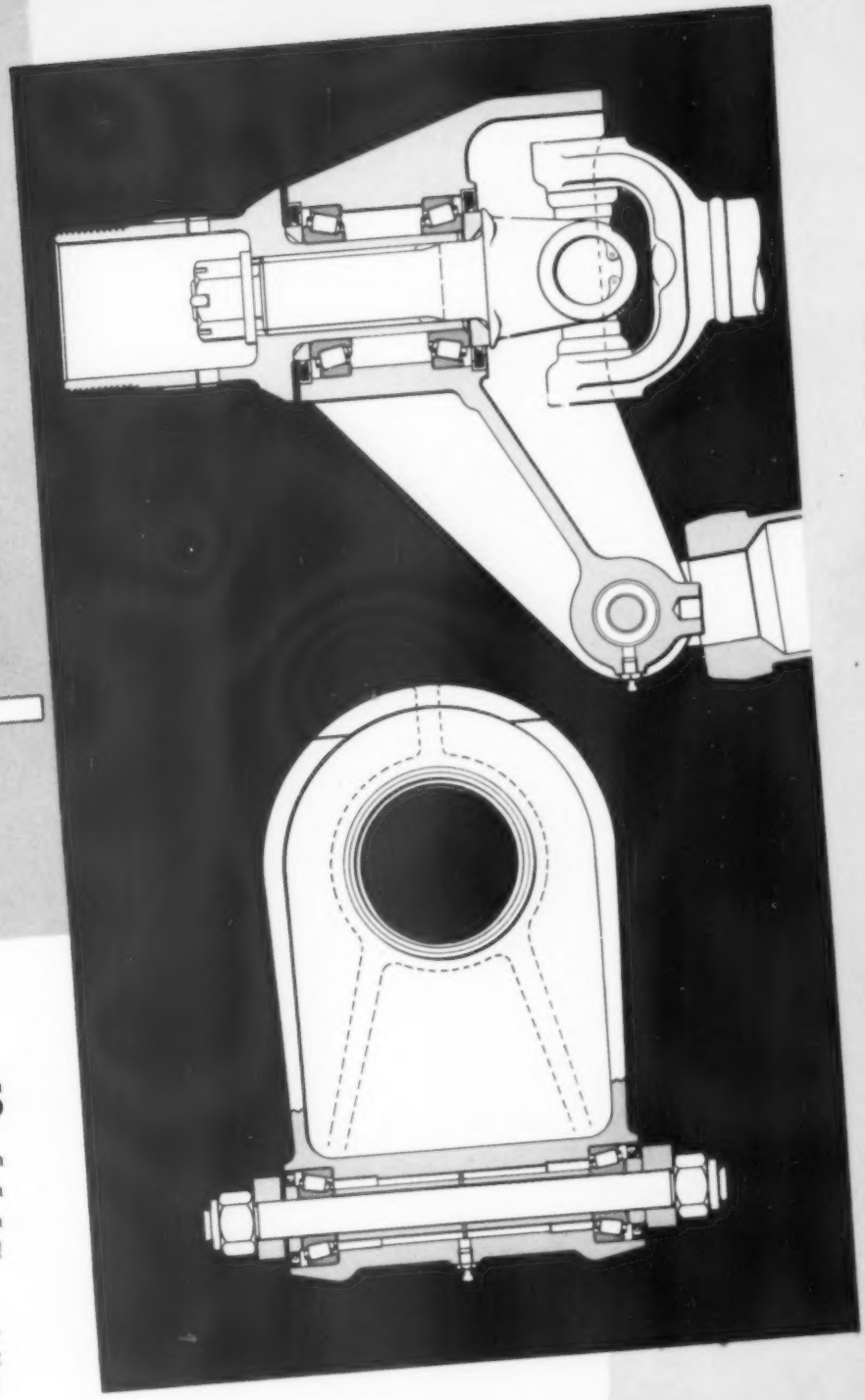


Interesting

In the new E-type Jaguar there are some interesting departures in design. The Salisbury final-drive unit—incorporating a Powr-Lok differential—has 'quarter-shafts' carrying the brake discs and universal joints. End location of the road wheels is effected by the cardan shafts, which also function as links in the suspension system; the journal and thrust loads arising from this arrangement are met by pairs of Timken bearings without loading the pair carrying the differential cage.

The rear suspension linkage is completed by tubular members journalled at their outboard ends to the rear-wheel bearing





applications

carriers by pairs of well-spread Timken bearings, a sound arrangement at a point where freedom without backlash is essential in so fast a car. The rear and front wheel bearings are self-evident.

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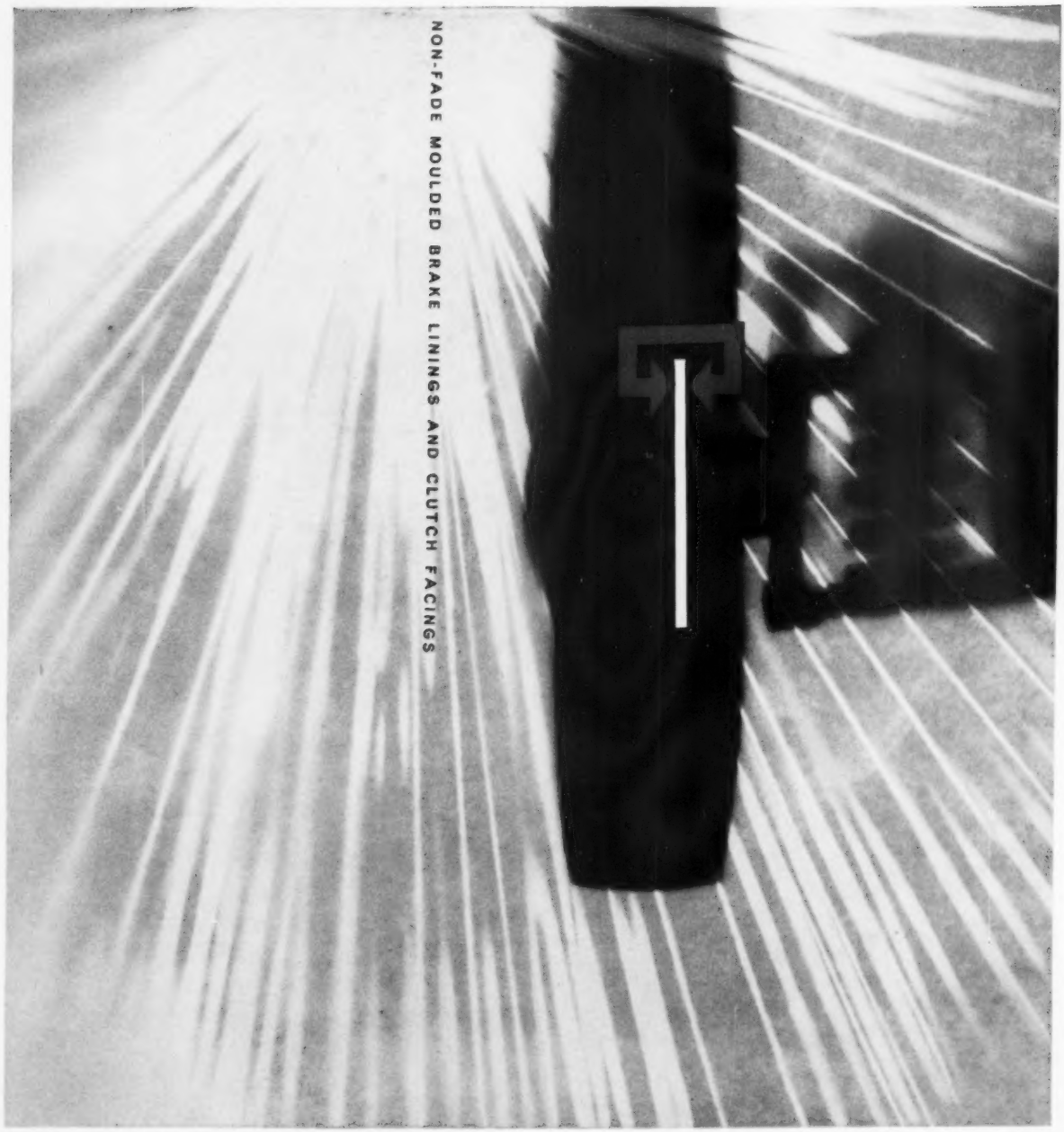

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For Cabs and Bodies

METALASTIK MOUNTINGS

Metalastik mountings play a double part in damping out vibration and shocks and reducing noise level. They help to give a better ride to the load which may range from the injured in an ambulance to sensitive electronic equipment and they prolong the life of coachwork and tanks by reducing local racking stresses.

The Metacone mounting is used extensively for widely different types of body. Providing substantial deflections with high load capacity, its progressive action and inherent damping are of great value.

Specially designed by Metalastik after long study of the problems involved in mounting cabs, the C.R. mounting is fitted by leading vehicle manufacturers. It reduces transmitted noise, softens shocks and controls rebound. There are many other mountings available. As a trunnion mounting or pivot for tanks, the Metalastik Ultra-Duty bush permits large torsional deflections and supports heavy radial loads. Cushyfoot mountings are ideal for mobile generators, compressors etc., and for lighter loads there is the low-height equi-frequency mounting with built-in rebound control as used for the sub-frame on the Rover 3-litre car.

Ultra-Duty bushes are employed for mounting aluminium tanks by Thompson Bros. (Bilston) Ltd. The Dennis ambulance chassis incorporates eight Metacone mountings to give smoother riding for the injured. Metacone mountings are used on the Tecalemit crashtender for cab and tank but they are larger than those on the ambulance because of severe shock loads on cross-country travel.

METALASTIK

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M.283

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Delrin* – the new versatile plastic that replaces metal

Delrin is used in many applications in Europe as in the U.S.A. where metal once was standard. In the motor industry, window winders, windscreen wiper gears, speedometer gears and heater blowers are typical examples.

Delrin is stiff, tough and dimensionally stable and retains these properties under exposure to solvents and high temperatures. It can be economically moulded into complex parts.

Delrin gives an excellent surface finish, is stain resistant and warm to the touch. Its natural whiteness and high degree of crystallinity give whatever colours are chosen a remarkable depth and sparkle.

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☐ ALATHON† — polyethylene resin
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☐ TEFLON† — fluorocarbon resin
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DELRIN HAS:

	OVER TEMPERATURE RANGE −40°C +125°C −40°F +258°F
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2. High modulus of elasticity	445,000 psi to 89,000 psi
3. Good impact strength	Izod. 1.2 to 1.4 ft.lb/in.
4. Excellent resistance to fatigue	5,000 psi 73°F
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6. Abrasion esistance	Good th o. ghout range
7. Moisture absorption	Low throughout range
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Plastics

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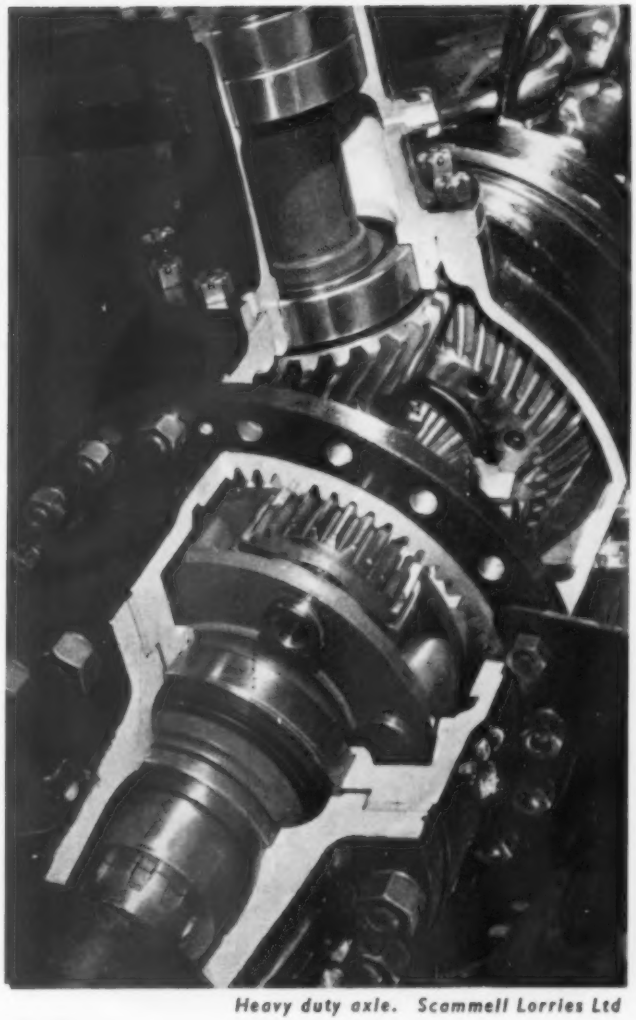
by

FIRTH-DERIHON

SHEFFIELD & DARLEY DALE

A 16mm. Colour Film with sound commentary, entitled "Drop Forgings in Alloy Steels," is available on request.



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BOTH SIDES

FROM HERE -WITHOUT

GETTING ROUND

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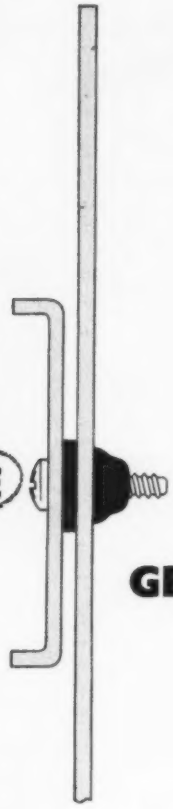

GKN *solve one-sided assembly problems with these New Low-Cost High-Speed Fasteners—*

* No tapping
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* High strength weight ratio
* No special tools required
* Vibration-proof
* Clips in position and cannot fall out
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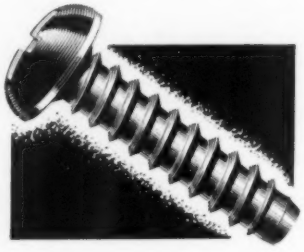
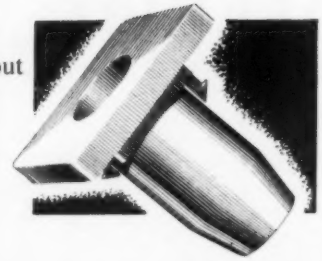
* Low cost



NPK Self-Tapping Screw



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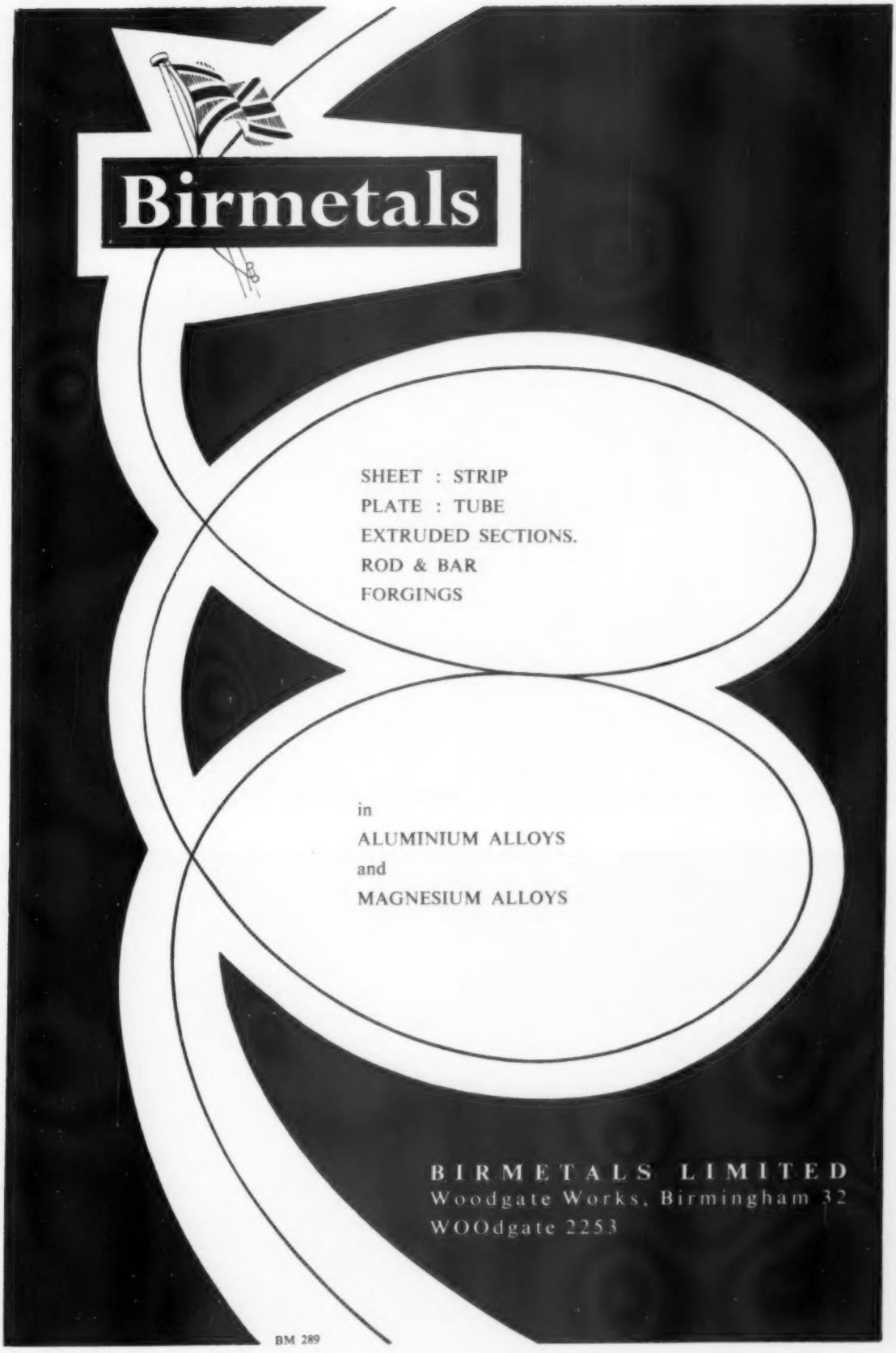
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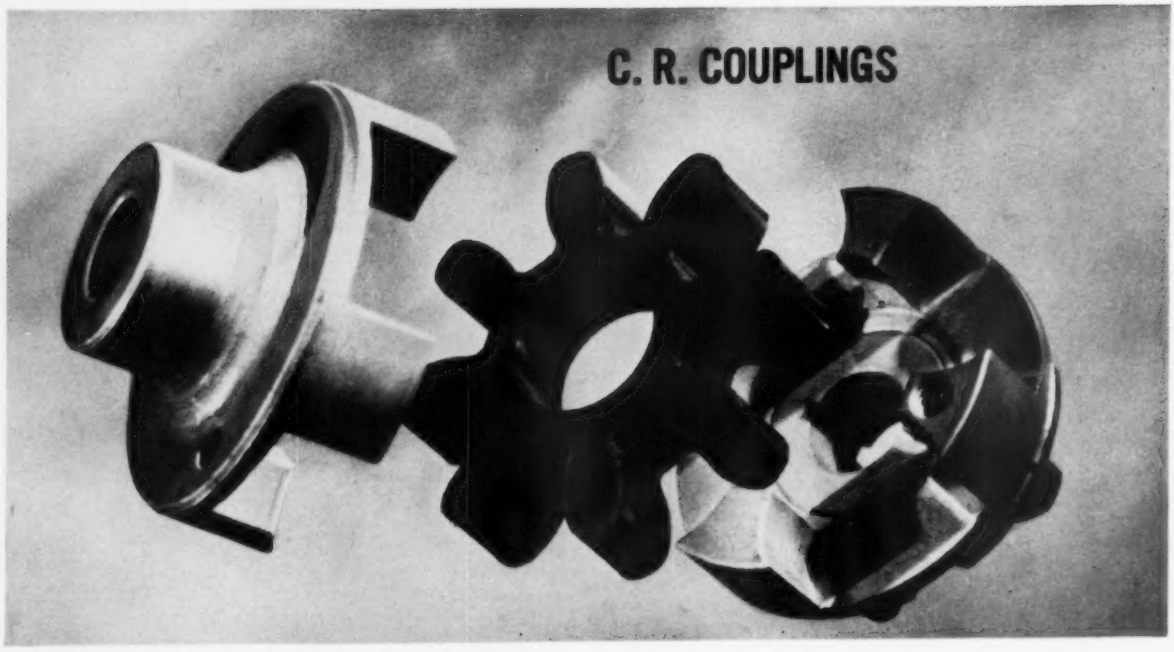
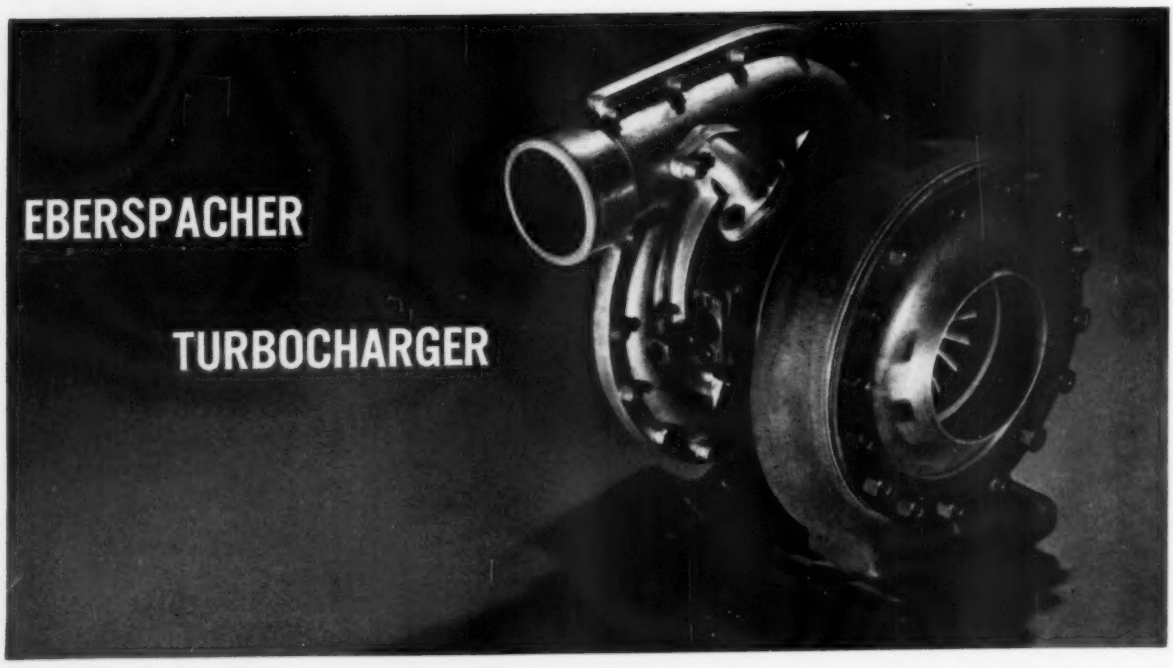
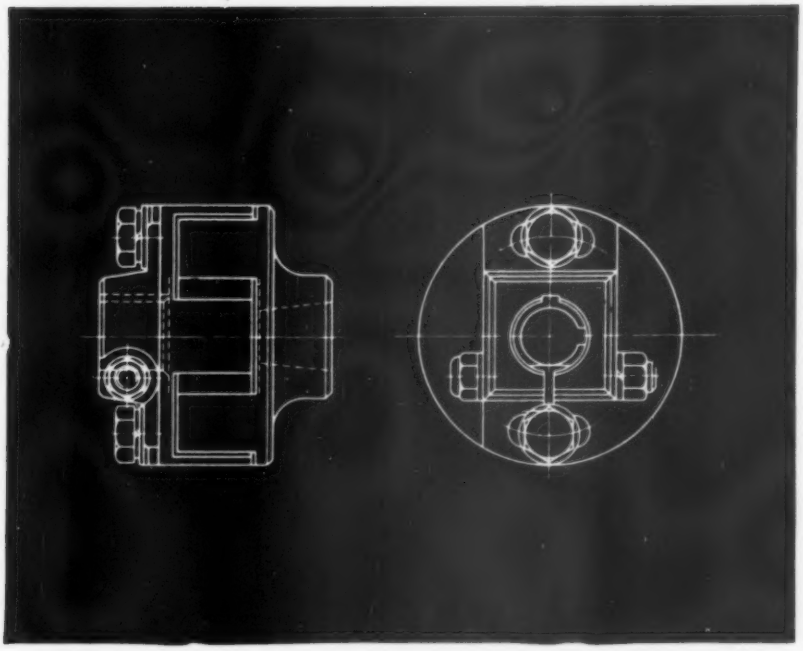
Simms

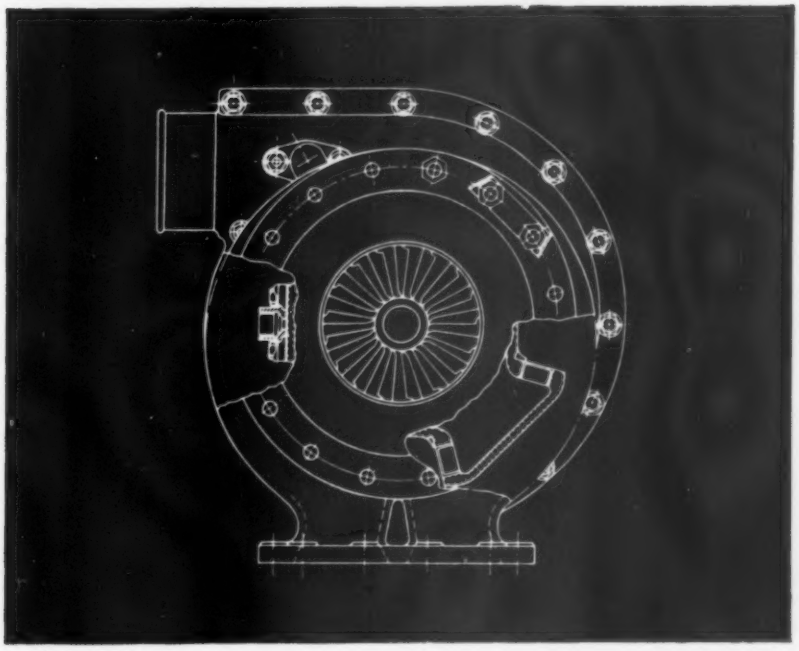




Simms



Simms C. R. Couplings are silent. They will accommodate small misalignment without wear or chatter. Any flexing takes place within the resilient insert—not by sliding.
This insert is of Nitrile synthetic rubber which is impervious to oil (eight times as good as Neoprene).
The coupling cannot be incorrectly re-assembled. Consequently accurate timing of driven equipment is maintained.



The Simms-Eberspacher Turbocharger uses waste heat energy in exhaust to provide more air for combustion; hence it enhances the power output from a given cylinder capacity with higher overall efficiency. Turbocharging increases flexibility; reduces smoke and the effect of altitude variations on engine performance.

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reliable thermostats

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01.

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DUO-DRY AIR CLEANERS

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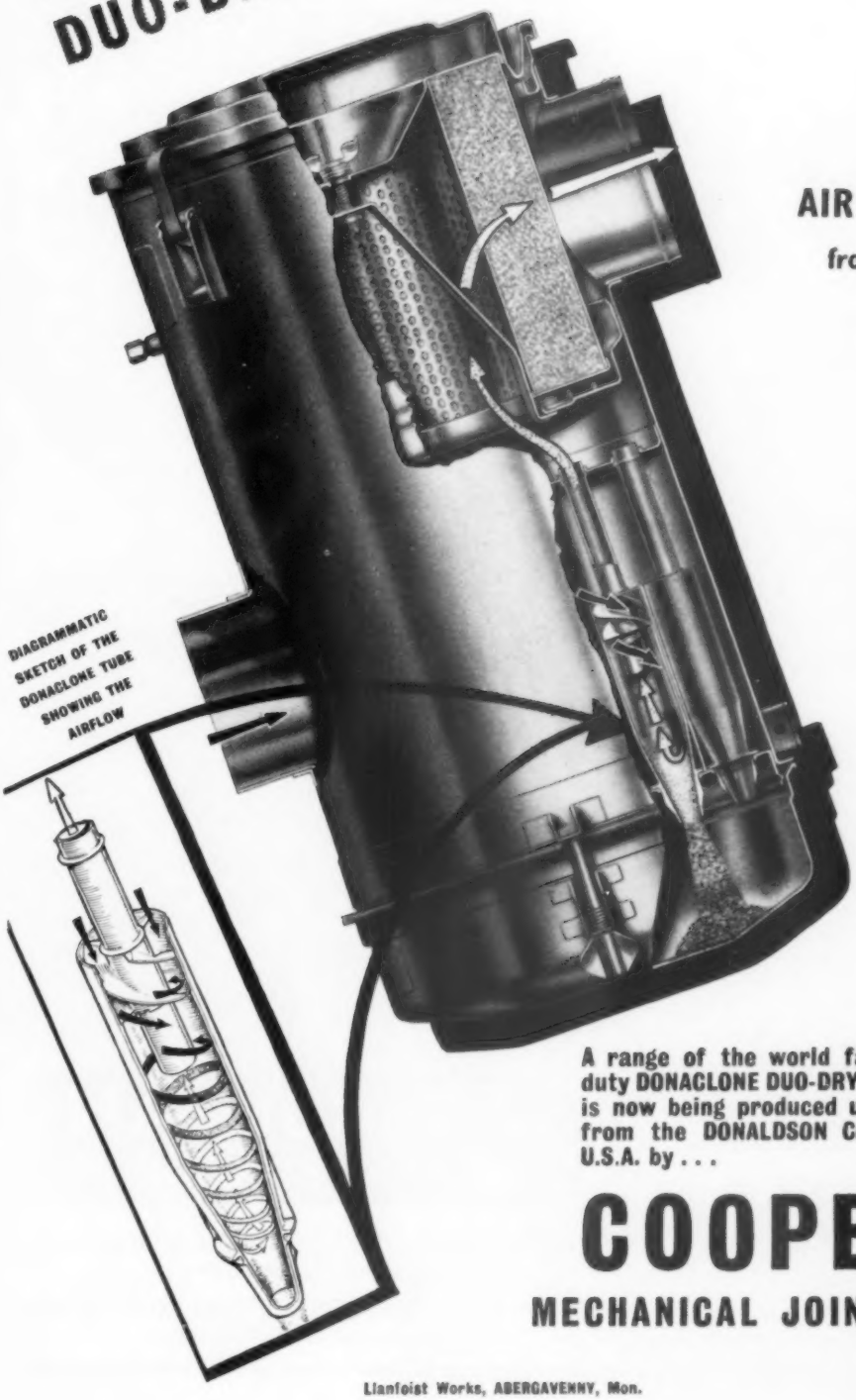

DIAGRAMMATIC SKETCH OF THE DONACLONE TUBE SHOWING THE AIRFLOW

AIR FLOW CAPACITIES
from **450** to **950** c.f.m.

Up to **98%** of foreign particles are removed by the primary centifruge stage, with the Long Life paper element bringing the overall efficiency up to **99.9%** as tested to B.S.S. 1701

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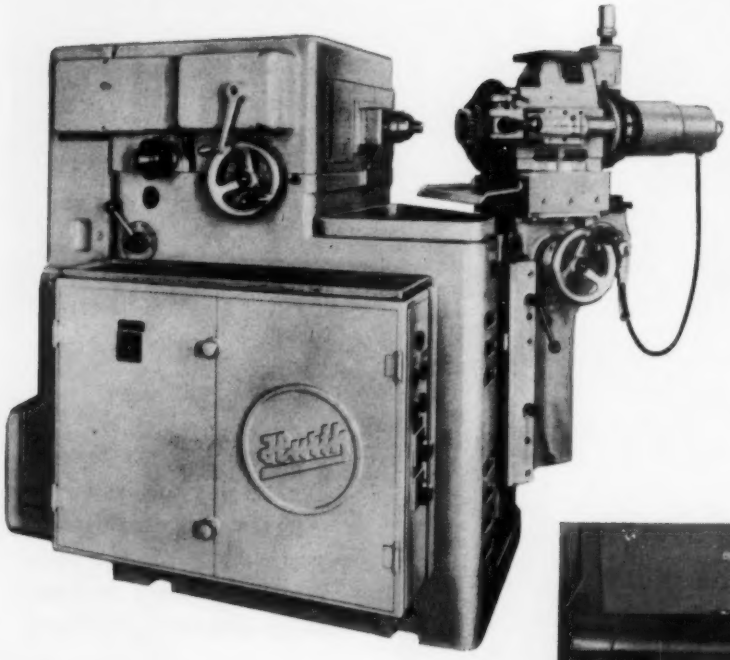

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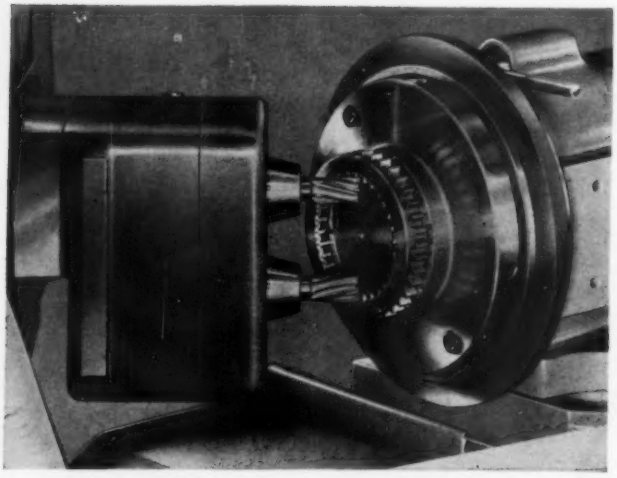

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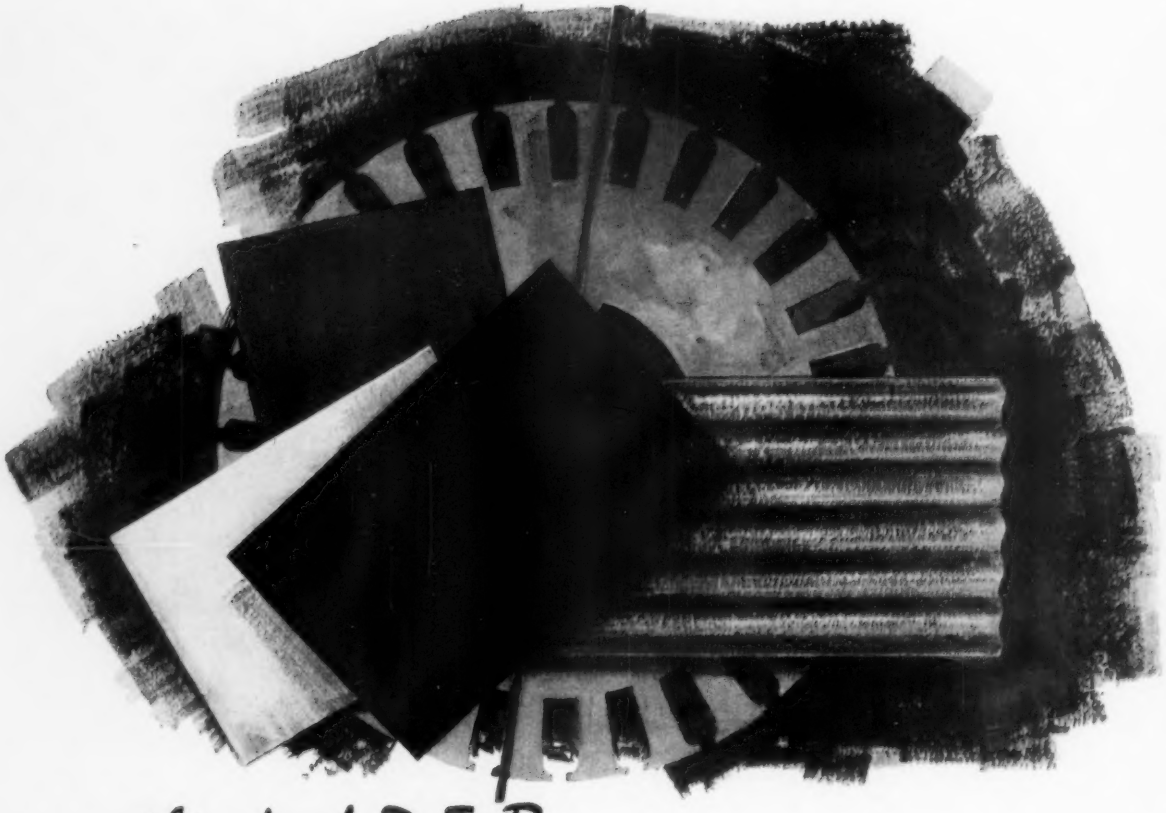

think of R·T·B

Our history comprises a long sequence of developments which have proved of far-reaching importance to industry and to the general public. In steel making, in the production of tinplate, sheet steel and strip, in the manufacture of special steels and laminations for the electrical industry, and specially coated sheets, the name of R T B has always been associated with leadership.

The illustration, with some latitude, serves as a reminder of R T B tinplate, black sheets and specially coated sheets—together with a corrugated 'Speltafast' galvanized sheet and, behind them all, a large electrical lamination, made by R T B from one of their special steels.

Latest R T B development: Europe's most modern steelworks and strip mill—Spencer Works—at Llanwern, near Newport, Monmouthshire. Construction is now well on the way and provision is being made for an initial output of 1,400,000 tons of ingot steel per annum.

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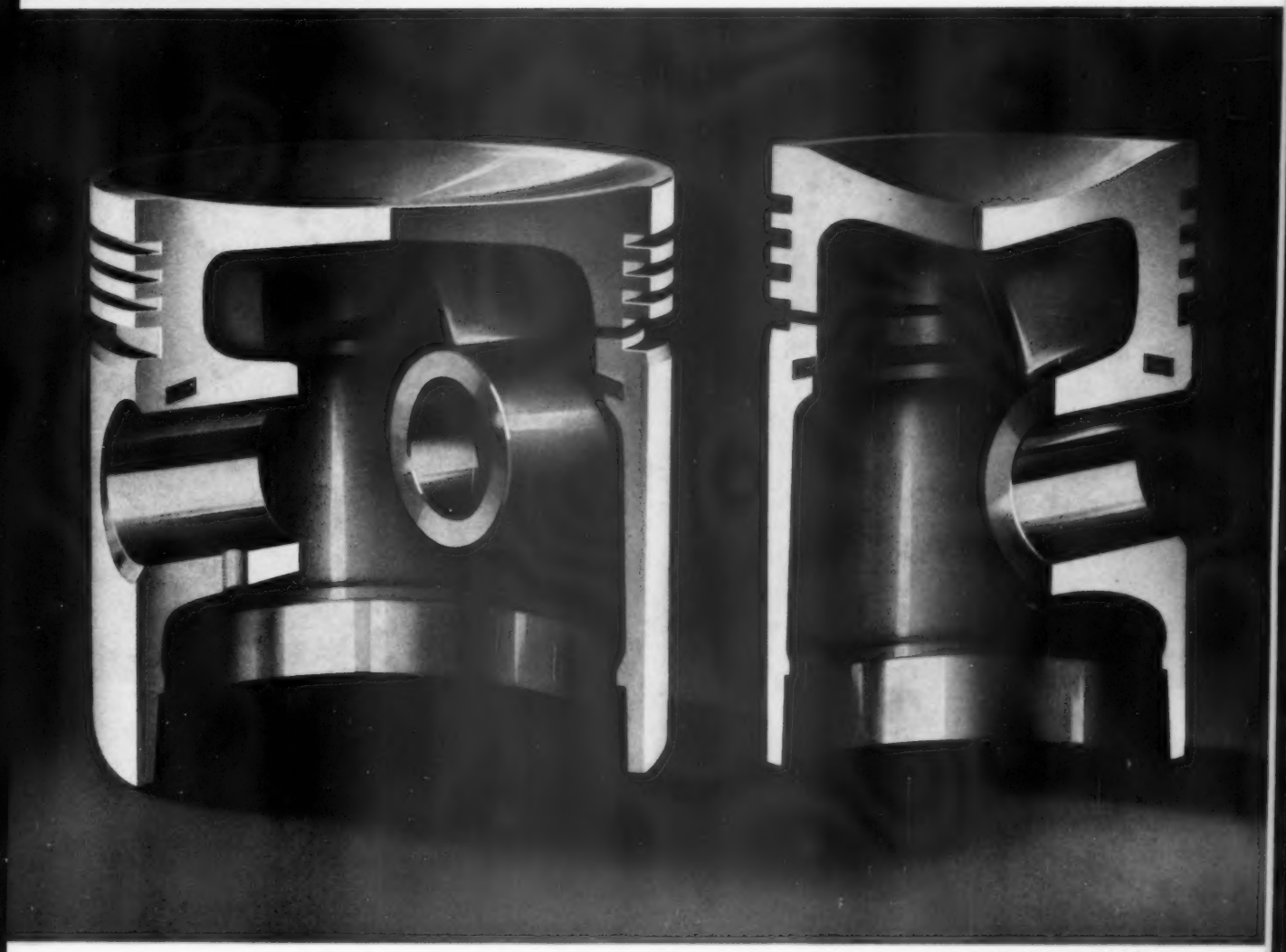

Provisional patent 4822/60

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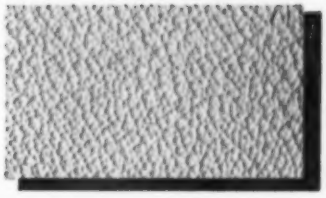
A TYPICAL SMALL CAR RADIATOR

'Artbrite' on a famous sports car. Photograph by courtesy of Lotus Cars Ltd.



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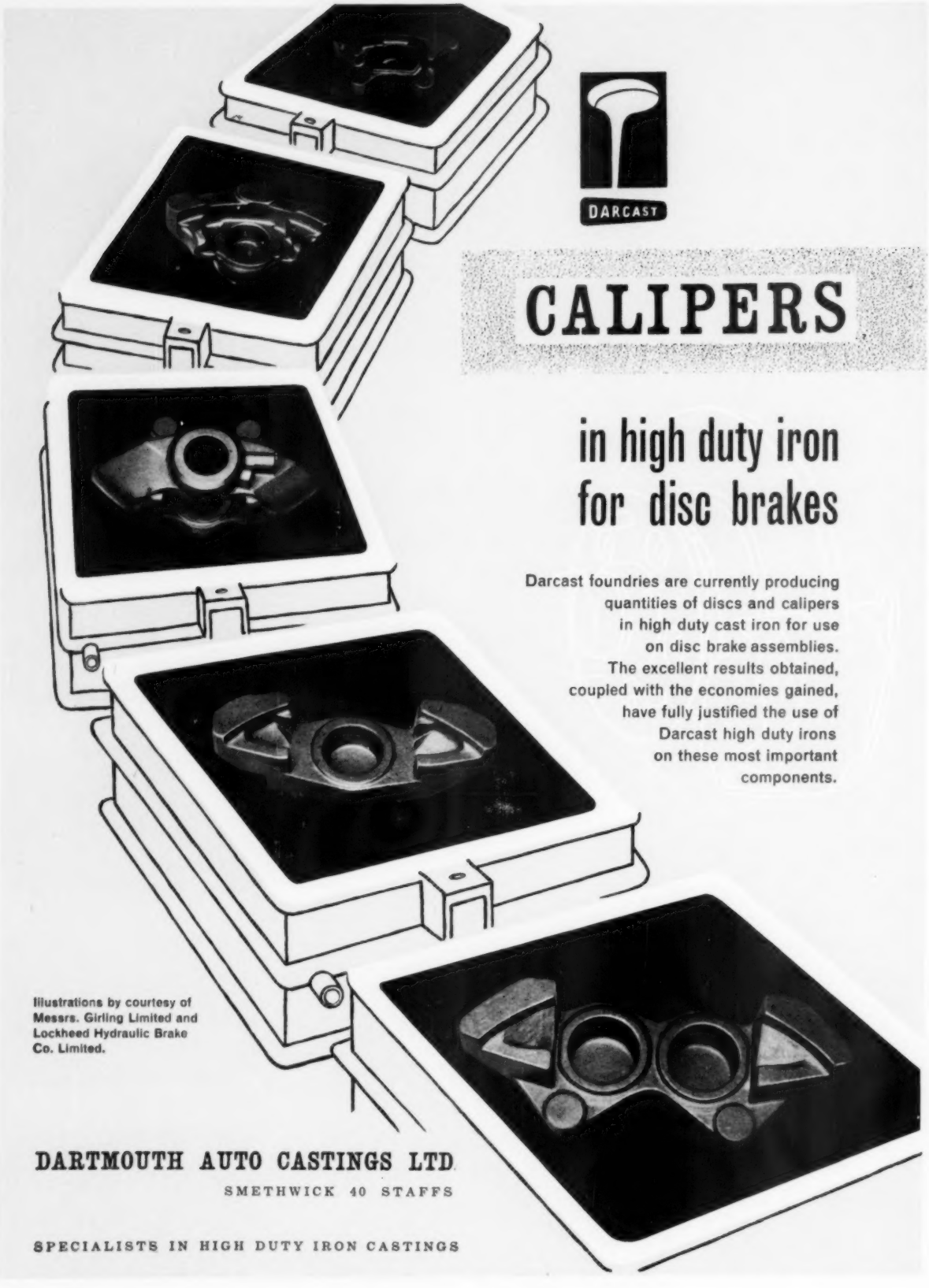

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CALIPERS

in high duty iron for disc brakes

Darcast foundries are currently producing quantities of discs and calipers in high duty cast iron for use on disc brake assemblies. The excellent results obtained, coupled with the economies gained, have fully justified the use of Darcast high duty irons on these most important components.

Illustrations by courtesy of Messrs. Girling Limited and Lockheed Hydraulic Brake Co. Limited.

DARTMOUTH AUTO CASTINGS LTD

SMETHWICK 40 STAFFS

SPECIALISTS IN HIGH DUTY IRON CASTINGS

AUTOMOBILE ENGINEER

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274 Larrad Hydrajaws *Multi-point, hydraulically-compensated, closed-circuit, clamping units for use in machine vices. Variants include hydraulically-operated clamps and some work-holding fixtures*

275 Aluminium Holding Furnaces *Wild-Barfield induction-heated, mains-frequency units specially developed for use in the Alumasc low-pressure diecasting process*

277 Hartex Centreless Grinding Machines *New models have a wheel balancer and a compensator for wheel-dressing angles*

279 Versatile Broaching Machines *500th "American" unit built by Coventry Gauge and Tool Co. Ltd.*

280 Machine Tool Research *New applied research department set up by Alfred Herbert Ltd, at Coventry*

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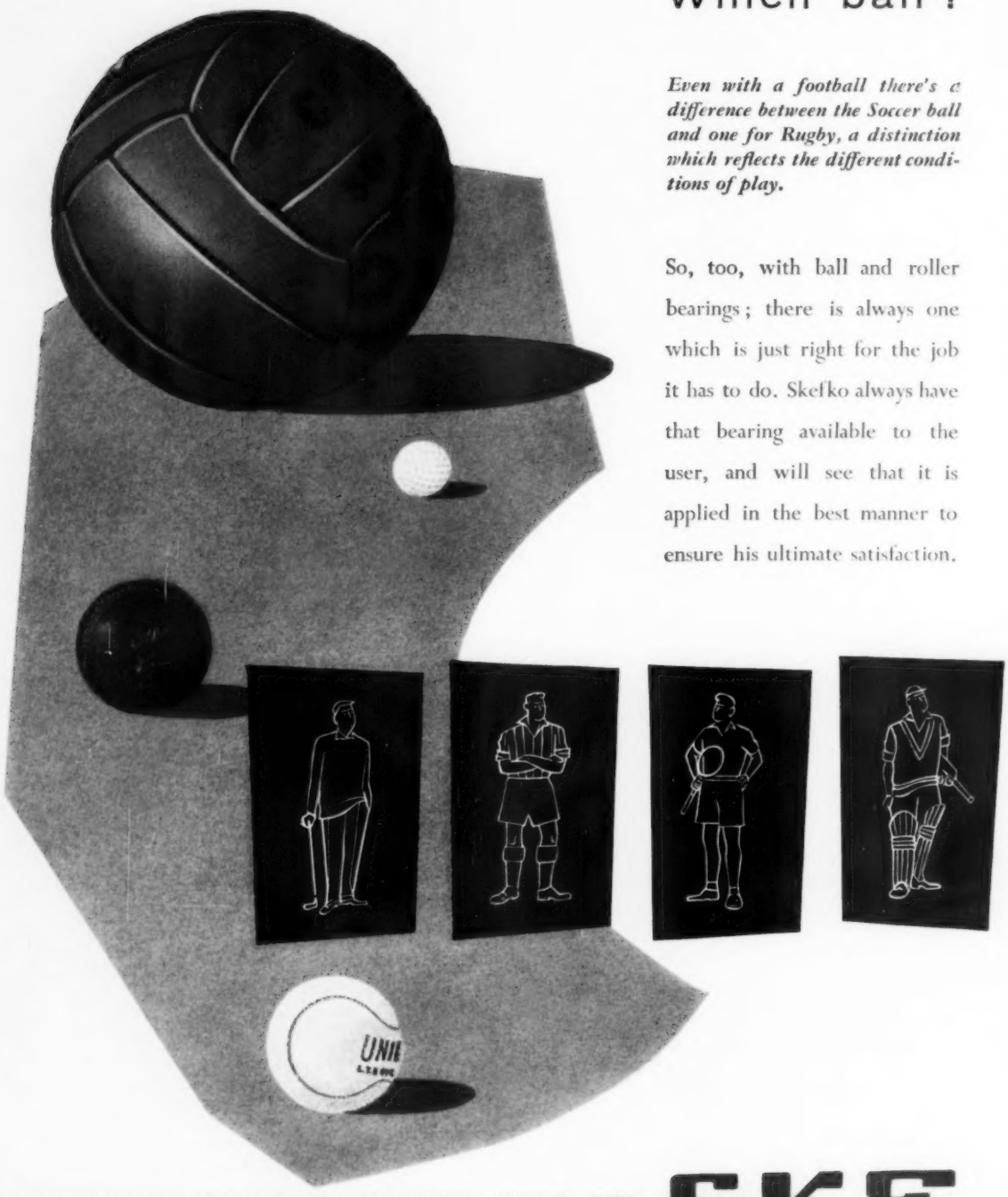

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AUTOMOBILE ENGINEER

DESIGN · MATERIALS · PRODUCTION METHODS · WORKS METHODS

Octane Requirement—Excessive Scatter

EXTENSIVE road testing of large numbers of the latest vehicles has shown that the fuel anti-knock requirement for apparently identical cars may vary by as much as 24 octane numbers. Although for a long time it has been suspected that the requirements of individual engines vary appreciably, the extent of this variation, details of which have been gleaned on our visits abroad, will come as a shock to many. The implications are serious.

So far as the manufacturers of cars are concerned, the validity of prototype engine and vehicle performance test results is at stake. Car owners whose hearing is normal, and who realize that damage can be done to an engine under knocking conditions, may in many instances be irritated by having to restrict their acceleration to avoid the onset of detonation—unless they are prepared to buy the most expensive grade fuels—while those who are less knowledgeable on technical matters, or who do not hear the pinking, are liable to experience premature engine failure and be faced with heavy repair costs. In either case, manufacturers can hardly view with equanimity the risk of loss of goodwill. The oil companies, too, are in an unenviable position: when it comes to the choice of blends of fuels for marketing for use in currently produced cars, either they have to accept the fact that a proportion of their customers will be dissatisfied, or they must face the extra cost of making provision for the worst cases and adjust their prices accordingly.

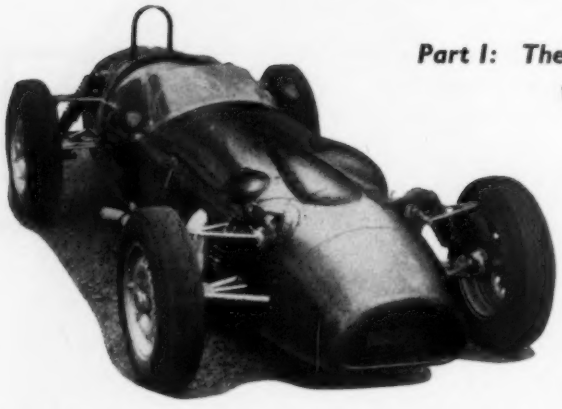
Admittedly the scatter of 24 octane numbers previously mentioned is the worst so far encountered, but lest it be thought that it is an isolated case, here are more details. With another make of vehicle, a scatter of 20 octane numbers was obtained, and values of 17 and 18 are common among cars of British and other European manufacture. All these results were obtained with small and medium size, quantity produced, family saloon cars in normal use, with their ignition settings as found. In each case the models were also tested with the ignition reset carefully according to the manufacturer's recommendation: in these circumstances, the model that was previously quoted as having a scatter of 24 had one of 10 octane numbers, while the other model mentioned had a scatter of 12·5. With the ignition setting corrected, scatters in excess of 10 octane numbers are still common.

From the results, two points emerge. One, of course, is that ignition setting is a significant factor and, from this, it can be concluded that the accuracy of operation of automatic advance and retard mechanisms is critical. The second is that in several instances where four and six cylinder engines are manufactured on the same production line, the four cylinder units show the smaller scatter. It would appear, therefore, that mixture distribution is another important factor, so especial attention should be paid to the layout, including port alignment, of induction manifolds. Among the other aspects that might be considered are the effects of piston design, sparking plug form, manufacturing tolerances in so far as they affect compression ratio, and design and surface roughness of combustion chambers.

Obviously there is a strong case for an intensification of efforts to determine what are the factors of greatest significance, so that manufacturers can take the most effective corrective measures: otherwise effort and unnecessary expense might be wasted in undertaking modifications that give no more than marginal benefits. Clearly the remedies lie within the province of the manufacturers of engines and their components. Since, however, the oil companies will also benefit, it can be assumed that they would be prepared to contribute to the work on an international scale. Indeed, with their extensive research resources, they have already achieved a great deal that has been of immense value to vehicle and engine manufacturers. So far as Great Britain is concerned, the Motor Industry Research Association, with its highly qualified staff and excellent facilities, is perhaps in the best position at least to co-ordinate the work, even if their current commitments are too great for them to be able to contribute a great deal to it.

FERGUSON RACING CAR

Part I: The Engine and Transmission System of a 1½ Litre Vehicle Built by Harry Ferguson Research Ltd. for Experimental Purposes



The Ferguson Project 99 car is unusual today in that the engine is ahead of the driver, and it has an unusual four-wheel drive system

ALMOST every racing car can, within limits, be regarded as an experimental vehicle, in that its constructor is constantly endeavouring to improve it by the close analysis of its performance and behaviour. However, the new Ferguson racing car—designated Project 99—has an entirely different basic function from others of its type: it is essentially a research apparatus, built by Harry Ferguson Research Ltd. as part of a programme for the development of various unconventional features. As is now widely known, these features—which mainly concern the transmission and braking systems—have already been thoroughly evaluated in other types of vehicle, both on and off the road. The new car permits the logical extension of the programme to cover high-speed conditions of the utmost severity.

Project 99 is intended to serve two purposes, the first of which is, of course, to assess the mechanical reliability of the unorthodox elements of the design, and to enable any modifications necessary to be tried. The second purpose is to prove publicly the advantages claimed by the company for the inventions concerned. It was felt that this could best be done by competing against vehicles that, in other respects, are directly comparable.

For those readers who are unfamiliar with the origins of Harry Ferguson Research Ltd, a brief explanation may be of assistance, as a preface to the description of the car. The late Harry Ferguson, an engineer of great vision and ability, was responsible for the Ferguson tractor which, in conjunction with his system for the hydraulic actuation of implements, has played an important part in the post-war mechanization of farming all over the world. In 1948 he sued the American Ford Motor Company for infringing the patents of this system and, after five years of litigation, won his case, obtaining damages of no less than £3,600,000. From 1946 to 1959, Ferguson tractors were built in quantity by the Standard-Triumph group, first for Harry Ferguson Ltd, and then for Massey-Ferguson Ltd; the latter company was formed in 1953 by the merging of Harry Ferguson Ltd. with the Canadian Massey-Harris Company. Subsequently, the Standard-Triumph tractor plant was bought by Massey-Ferguson Ltd, from which Ferguson withdrew in 1954.

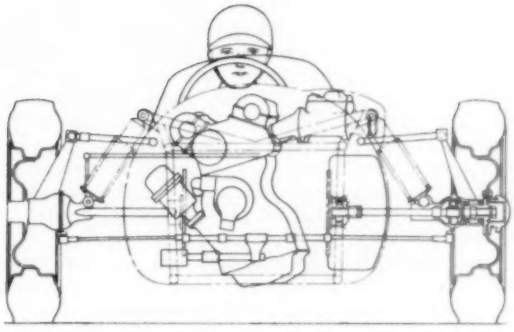
Harry Ferguson Research Ltd. was established in 1950 as a research nucleus quite separate from the original Ferguson organization. Its activities have been devoted to the investigation of one of Ferguson's most strongly held beliefs, namely that the safety of any road vehicle was bound up to a great extent with its ability to maintain traction. Work in this direction has continued for eleven years, in spite of the death of Harry Ferguson in 1960, and impressive results have been achieved. Although no car manufacturer has yet adopted the Ferguson principles, it is known that several have shown considerable interest.

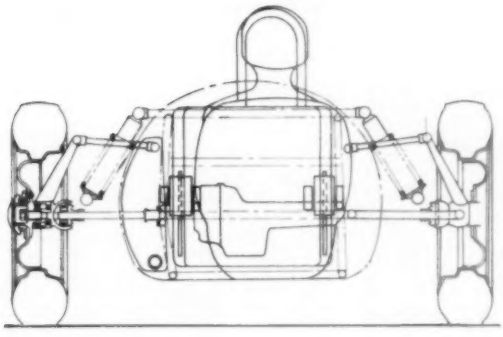
The racing car has been built to comply with the current Formula 1 regulations of the F.I.A, and it is powered by the now-familiar Coventry Climax FPF 1½ litre four-cylinder engine in its latest, Mark II form. Since, at the time of writing, this power unit is used by all the other British constructors participating in this category, the variable of engine performance is virtually eliminated from any comparisons. The design of the car shows two major departures from orthodox practice: all four wheels are driven—in such a manner that the torque delivered to each pair is directly related to the available traction—and their locking under braking is prevented by the ingenious application of a single Dunlop Maxaret unit, the principle of operation of which was described in the July 1958 issue of *Automobile Engineer*. Since these two features ensure the optimum use of both engine and braking torques, and ensure the highest possible cornering power, it is reasonable to assume that the all-round performance, particularly on slippery surfaces, should be superior to that of an equivalent conventional car, while the demands made on the driver should be reduced, though his technique might require modification to get the best results.

In its general layout, the Ferguson vehicle is unfashionable in that the engine is ahead of the driver. The designers felt that, because the tractive effort could be equally distributed between the front and rear wheels, it was logical to distribute the weight similarly, and this arrangement would also give the best basic handling characteristics; a balanced weight distribution is clearly simpler to obtain, within a given overall length, when the engine is in front of the driver than when it is behind him.

A reasonably short wheelbase is made possible by offsetting the driver towards the right of the car, so that his legs are alongside the gearbox. To facilitate this disposition the engine is installed at a compound angle in the space type chassis frame: as viewed in end elevation, it is canted over at 17 deg to the right; and, as viewed in plan, the crankshaft axis is inclined at an angle of 3 deg to the vehicle's longitudinal axis, the rear end being offset, of course, to the left. Not only does the canting over of the engine bring the crankshaft towards the left without displacing the mass centre, but it also reduces the height of that centre, and minimizes the frontal area of the body. It is worthy of mention that the highest point of the power unit is only 16½ in from the ground.

Although the admirable Coventry Climax engine is now so well known, a brief review of its salient features may be helpful. The main differences between the Mark II version and its predecessor consist of an increase of approximately 0·6 mm in the bore diameter, and modifications to the inlet





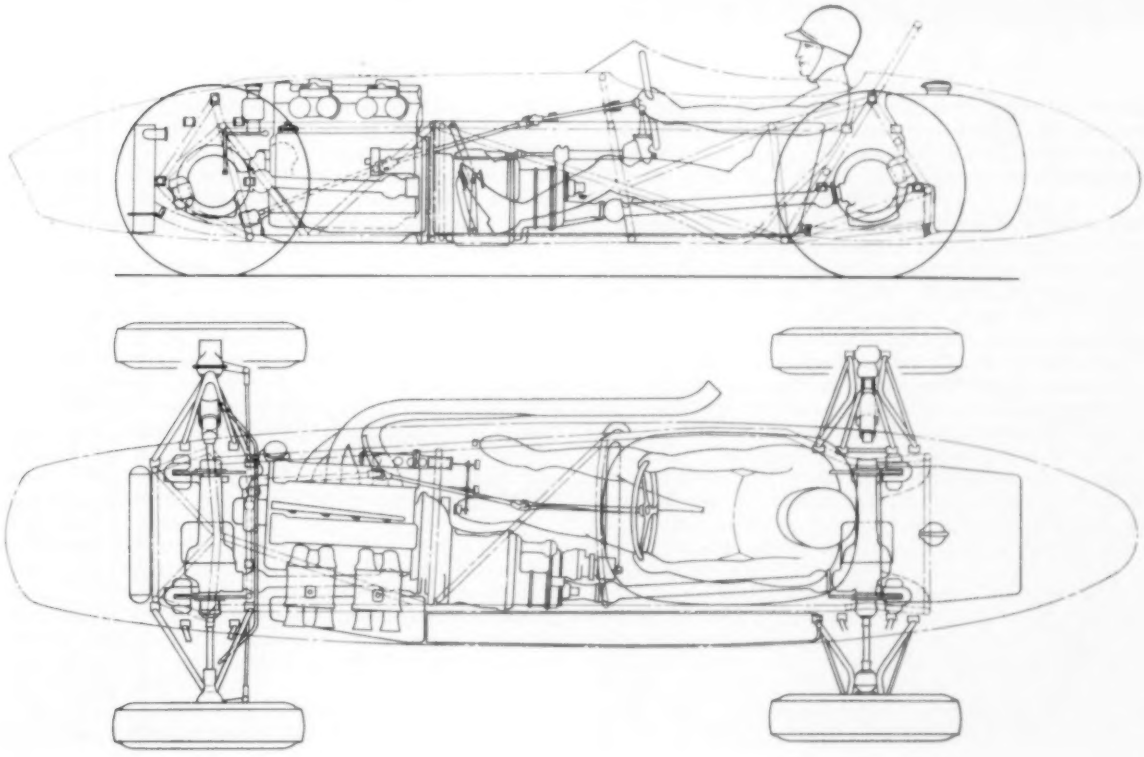
General arrangement of the vehicle. The engine is canted over in the frame and, as viewed in plan, the crankshaft axis is inclined relative to the car's longitudinal axis, to bring the gearbox alongside the legs of the driver, who is offset to the right. The wheelbase and front and rear tracks are respectively 7 ft 6 in, 4 ft 4 in and 4 ft 2 in; and the overall length, width and height are 12 ft 11 in, 4 ft 10½ in and 2 ft 9 in

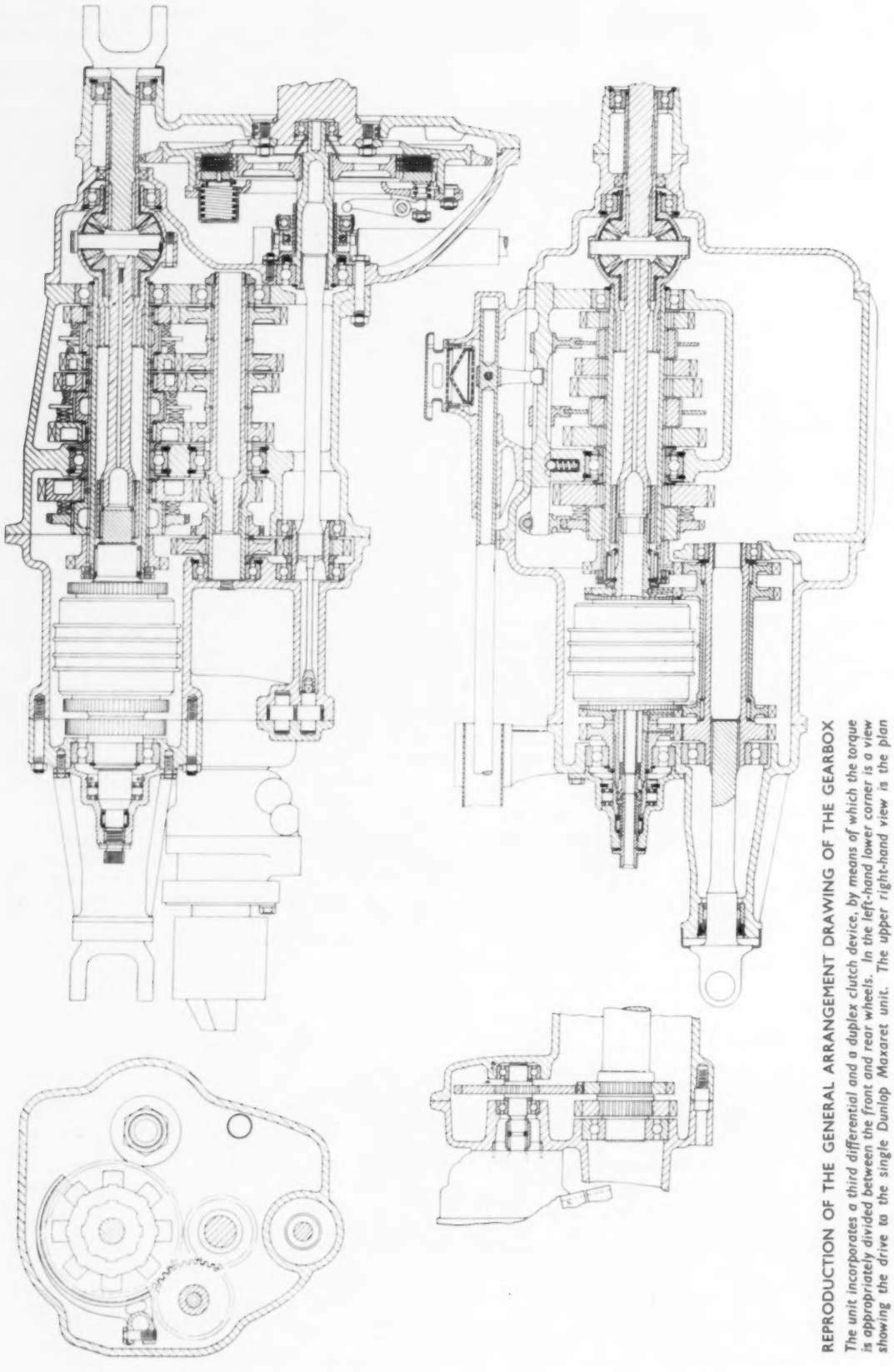
and exhaust ports. This enlargement of the bore, to 81·9 mm, has raised the swept volume from 1,475 cm³ to 1,498 cm³, the stroke remaining at 71·1 mm.

Both the crankcase-block unit and the cylinder head are light alloy castings, and the crankshaft has five main bearings. The two overhead camshafts are gear driven and actuate the valves — which are inclined in part-spherical combustion chambers — by means of inverted bucket type tappets. There is one sparking plug per cylinder, and the compression ratio is in the region of 11 : 1. Fuel is supplied to the two Weber 45 mm twin-choke carburettors by a mechanical pump, driven from the rear end of the inlet camshaft. In the Ferguson installation, a Marston cross-flow radiator is carried ahead of the final-drive unit for the front wheels, and to its underside is bolted an oil cooler.

The maximum power output of the Mark II engine is approximately 150 b.h.p. at 7,500 r.p.m, equivalent to almost exactly 100 b.h.p/litre and 4·61 b.h.p/in² of piston area. For a racing unit, the torque curve is relatively flat and is at its peak of 117 lb-ft from 5,000 to 6,000 r.p.m. The corresponding maximum b.m.e.p. is 193 lb/in². Complete with the carburettors, starter motor and flywheel, but without the clutch, the engine weighs 288 lb dry, so its power : weight rate is 0·52 b.h.p/lb. Alternatively, for Intercontinental Formula races, the Coventry Climax 2½ litre engine can be installed.

Although the four-point mounting of the engine and gearbox assembly is not flexible in the present-day sense, it incorporates rubber bushes to reduce the transmission of vibration to the frame. Because of the compound inclination of the engine, and the presence of the transmission on the left side, the mounting arrangement is, of course, asymmetrical. Each front mounting consists of a Silentbloc bush and an engine bearer bracket: the bush is carried in a welded-on housing on the frame, adjacent to the lower side rail, and its axial bolt is screwed into a boss on the bracket, the other end of which is secured to a facing on the





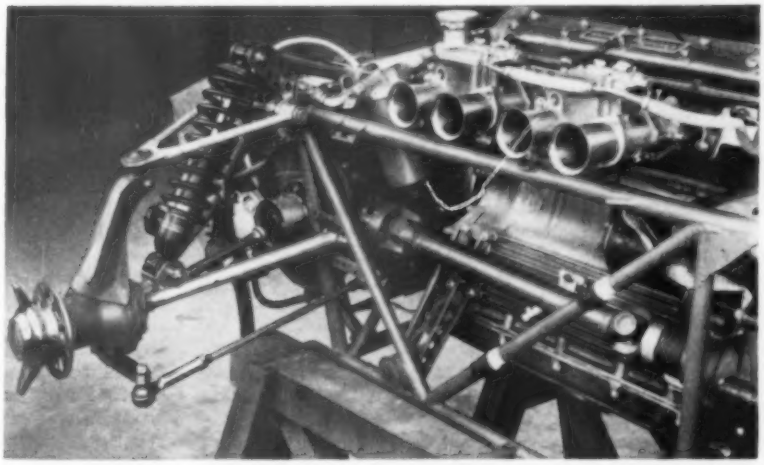
REPRODUCTION OF THE GENERAL ARRANGEMENT DRAWING OF THE GEARBOX

The unit incorporates a third differential and a duplex clutch device, by means of which the torque is appropriately divided between the front and rear wheels. In the left-hand lower corner is a view showing the drive to the single Dunlop Maxaret unit. The upper right-hand view is the plan

side of the crankcase by means of four studs and stiff-nuts.

The right-hand bearer, which is the shorter of the two, comprises two 12 s.w.g. steel tubes welded together to form a V. At the apex is the boss for the axial bolt of the Silentbloc bush, and the ends of the arms are welded to the carrier plate, of $\frac{3}{16}$ in thick material. The boss and carrier plate of the left-hand bearer, which is shown in one of the accompanying illustrations, are similar but the bracket itself is fabricated from sheet steel. It consists of two side members of channel section, facing outwards, separated by a flat web. All three components are drilled to minimize weight, and the side members taper in depth from the crankcase end of the bracket. The web is disposed diagonally, in that its outboard end is level with the upper flanges of the side members, while its inboard end aligns with the lower flanges.

On the clutch bell housing are two lugs to which the fabricated rear bearer member is bolted. This member is disposed transversely and horizontally, and is of channel section. At each end of it is a housing for a Silentbloc bush of a type similar to those at the front. The bolts that pass through the inner sleeves of these bushes screw into bosses on the frame, just below the level of its top rails.



At the front, the Coventry Climax 1½ litre engine is carried on Silentbloc bushes housed on the frame; fabricated bearers are bolted to faces on the crankcase. In this view, the propeller shaft to the front final-drive unit is visible, but the unit itself is partially masked by the brake disc. Each half-shaft is fitted with two Birfield constant-velocity universal joints

Transmission system

Attached by studs to the rear of the engine is an adaptor casting, to which the bell housing is similarly secured. Both these castings, and the casings of the gearbox and final-drive units, are of magnesium alloy and were produced by Sterling Metals Ltd. Within the bell housing is a three-plate clutch, which has an effective diameter of 6$\frac{7}{8}$ in. The clutch was designed by Harry Ferguson Research Ltd. in collaboration with the Italian engineer Colotti, of Gear-Speed Developments, who has acted as a consultant also in connection with various gear tooth problems in connection with the transmission.

Whereas the driving plates and the pressure plate are plain steel, the driven plates carry bonded-on button type facings of sintered bronze, manufactured by Morgan Crucible Co. Ltd. There are 20 of these buttons, which are 0·025 in thick, on each side of each driven plate. Since the diameter of the buttons is $\frac{3}{8}$ in, the effective friction area of the 20 is 6·136 in^2.

The driving plates have peripheral dogs that register in axial slots within the forged, En.9 flywheel, which is located on the crankshaft by a spigot and attached thereto by eight $\frac{5}{16}$ in bolts. Dogs on the driven plates register similarly in the periphery of the clutch centre, which is an En.27 steel forging and is of wheel form, with lightening holes in the web. Splines are machined in the bore of the centre, which is a sliding fit on the corresponding splines of the output shaft.

The clutch clamping pressure is provided by nine helical springs, which provide a total thrust of 547 lb when the clutch is engaged and 727 lb when it is released. Because of the proximity of the clutch to the driver's left foot, the actuating mechanism is simple and direct. The pedal is linked to an external lever mounted on a transverse shaft protruding from the bell housing. On the inboard portion of the shaft is a fork registering in an annular groove in a sleeve, which is free to slide axially on a second, fixed sleeve embracing the clutch output shaft; the rear end of the fixed sleeve has a stepped flange, and is bolted to the bell housing. The sliding sleeve carries a ball thrust bearing, the free race of which, when the pedal is operated, is brought into contact with the inner ends of the three rocking type withdrawal levers on the clutch assembly.

Because of its heavy duty, the partially hollow output shaft of the clutch is a KE 805 forging. Its leading end, of 15 mm diameter, is carried in a ball bearing housed in the crankshaft in the conventional manner. Immediately behind this spigot portion of the shaft are the splines for the clutch centre, and behind the splines is the portion that lies within the fixed sleeve mentioned earlier. On to the rear end of the shaft, the diameter of which is 30 mm, is pressed the inner race of a ball bearing of 62 mm outside diameter. A circlip secures the inner race against an integral collar on the shaft. The outer race is housed in a boss in the bell housing, where it is retained between the flange of the fixed sleeve of the withdrawal mechanism and the end of the gearbox casing. A lip type oil seal is mounted within the stepped portion of the sleeve and bears on the periphery of the collar.

To permit rapid changes of the overall gear ratio to suit various circuits, a primary reduction unit is interposed between the clutch and the gearbox. Since a degree of torsional flexibility in the drive is desirable, the primary reduction is at the rear end of the gearbox and is connected to the clutch by a resilient shaft, which is of KE 805 steel and has a diameter of 0·512 in. At each end the shaft is

upset, and the enlarged portions are serrated: one end is a sliding fit into corresponding serrations in the bore of the clutch output shaft, and the other fits similarly into the hub of the input gear of the primary reduction. The effective length of the shaft is 8 in and it has a torsional rate of 14 lb-ft/deg.

Both gears are of the straight spur type, of En.39B steel and with a face width of $\frac{7}{16}$ in. The input gear is an interference fit on the external splines of its hub, which runs in two ball bearings, each having a bore of 30 mm and an outside diameter of 55 mm. One of these bearings is housed in the main casing of the gearbox, and the other in the secondary casing to the rear of it. The output gear is mounted on splines on a rearward extension on the gearbox input shaft; this extension, which embodies the first gear and reverse pinions, spigots over the end of the shaft and is driven from it by splines. There is a choice of eleven primary reductions, ranging from 1·133 : 1 to 1·933 : 1, and the various tooth numbers and diametral pitches are given in Table 1.

The all-indirect gearbox provides five forward ratios. All the gears have straight teeth and are in constant mesh; engagement is effected by dog clutches of the staggered type, the principle of which was described in the November 1960 issue of *Automobile Engineer*. The special Colotti profile is used for the gears, which were produced in En.39B steel, by Ferguson Research, on Fellows machines. The finish provided by these machines is sufficiently good to obviate the need of subsequent grinding which, in any case, was regarded as undesirable owing to the difficulty of keeping the wheel trimmed to a satisfactory degree of accuracy. To minimize the risk of scuffing, all gears are treated by the Parco-Lubrite process.

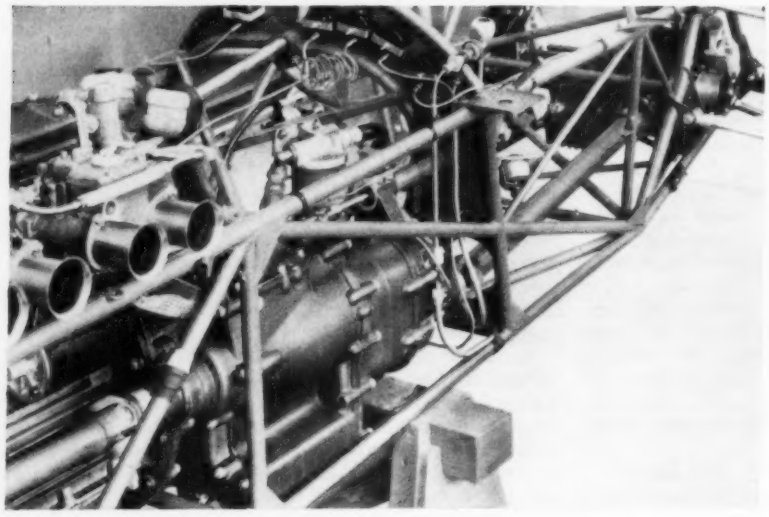
Since the axes of the torsion shaft and the input and output shafts of the gearbox are all in the same horizontal plane, and the various bearings of the transmission unit are housed in no less than five castings, accuracy of alignment is clearly of the utmost importance. Consequently, the dowels for the mutual location of the portions of the casing are all situated in the plane through the axes of the shafts, and the housings for the bearings are line bored by means of a jig borer. Alignment of the dowels is ensured by the use of a jig plate, which is transferred from one component to another when the dowel positions are being marked out.

The input shaft is a partially hollow forging of KE 805 steel, splined to receive the pinions of the upper four ratios. It is carried in two ball bearings, and the rear end of the extension previously mentioned runs in a third bearing of this type. The leading bearing is housed in the front wall of the main portion of the gearbox casing, and the second one is situated in a diaphragm type wall in this casing; between them are the pinions for the second, third, fourth and fifth ratios. Immediately behind the inner race of the second bearing, the shaft has an integral collar, against which the complete assembly of inner races and pinions is clamped by a nut on the leading end of the shaft. Longitudinal location of the assembly is effected by circlips, one on each side of the outer race of the second bearing. A circlip retains the outer race of the third bearing in its housing in the secondary casing of the gearbox. The inner race of this bearing is pressed on to the extension, which in turn is pressed on to the input shaft against the rear face of the collar referred to earlier in this paragraph.

The gearbox output shaft is an externally splined hollow forging of KE 805 steel. It is supported in two ball bearings —which are transversely in line with the first and second bearings of the input shaft—and is overhung beyond the rear one of these. At its leading and rear ends are respectively a circlip and a nut, between which are clamped the inner races of the bearings, the externally splined sleeves on which the sliding dog members are carried and—at the rear end—an additional gear, the purpose of which will be explained later. The ends of the sleeves are reduced in diameter to form the inner tracks for the needle rollers on which the gears revolve when idling. As in the case of the input shaft, the outer race of the second ball bearing is located by circlips.

Particulars of the gears are given in Table 2. The ratios provided are as follows: top, 1 : 1; fourth, 1·144 : 1; third, 1·353 : 1; second, 1·708 : 1; first, 2·5 : 1; reverse, 2·037 : 1. Gear selection is effected by an orthodox three-rod striker mechanism, situated above the gear cluster, and a remote control linkage extending back to a short lever to the left of the driver.

In that portion of the transmission system already described, there are no major departures from conventional practice. However, the remainder of the unit is unique and is covered by Patent 731,938. As has been indicated, the drive is divided equally between the front and the rear wheels, and a control device is embodied to ensure that, should one or both wheels of one pair tend to spin, torque is transferred from that pair to the other until the speeds



The gearbox, third differential and the control device assembly. On the input end of the gearbox is a primary reduction, for which eleven ratios are available, as a means of suiting the overall gearing to any particular racing circuit. Straight tooth pinions are employed in the gearbox, all the five speeds of which are indirect; the engagement of gears is facilitated by the use of staggered type dog clutches

are again synchronized. Conversely, the device also resists any tendency to locking of one or both wheels of a pair. In essence, it consists of a third differential and a duplex clutch assembly.

The differential is of the four-pinion type and is situated ahead of the gearbox, in a compartment extending leftwards from the bell housing. Its cage is of the split type : the rear half has a splined extension, which registers in corresponding splines within the leading end of the output shaft of the gearbox, while the front half has a shorter extension pressed into the inner race of a ball bearing; the outer race of the bearing is retained in the wall of the compartment in the bell housing by a circlip. All six gears are of En.39B steel, and there are 10 teeth on the pinions and 16 on the output gears.

Both output gears have extended and internally splined bosses. The boss of the leading gear is the longer of the two, and the splines are at its rear end; the greater length is necessary to ensure adequate support for the yoke shaft of the first universal joint in the drive to the front wheels. The splines on the yoke shaft are a sliding fit in the boss, to permit reasonable tolerances in the transmission line, though virtually no sliding occurs once assembly is completed. Carrying the leading end of the boss is a ball bearing, installed in the front wall of the casing and secured by a circlip. Immediately ahead of the bearing carrying the cage is an oil seal that bears on the boss.

There are also splines in the boss of the other output gear; in these splines, with a similar sliding fit to that of the yoke shaft, registers a shaft that lies coaxially within the output shaft of the gearbox and extends just to the rear of the first gear pinion. The rear end of this inner shaft is splined and is connected by a muff coupling to a further shaft, which passes through the duplex clutch unit. Immediately to the rear of this unit the shaft is splined, and on the splines is mounted a gear, the hub of which is carried in a ball bearing housed in the end cover of the secondary portion of the gearbox casing. Meshing with this gear is another of the same size, which is integral with and near the rear end of a hollow shaft about 7 in long; this hollow shaft lies below the other and runs in two ball bearings, one at each end. The bearing at the rear end is carried in the end cover just mentioned, and the other is pressed into a boss in an internal wall within the secondary casting.

A rearward projecting portion of the end cover, coaxial with the hollow shaft, houses a needle roller bearing that carries the yoke shaft of the first universal joint in the drive to the rear wheels. Oil leakage through this bearing is prevented by a lip type seal. The leading end of the yoke shaft is splined and is a sliding fit in corresponding splines in the bore of the hollow shaft : again the objective is to avoid undesirably tight tolerances.

For most of its length ahead of the gear, the hollow shaft is embraced by a sleeve member; at each end of the sleeve is a needle roller bearing, the tracks of which are formed directly in the sleeve and on the shaft. Three gears are forged integrally with this sleeve member : the leading gear of the three meshes with the rearmost gear on the output shaft assembly of the gearbox, while the other two gears mesh with additional gears one at each end of the duplex clutch unit. Each of these last-mentioned gears is integral with one half of the casing of this unit, and floats on the shaft from the third differential.

At the present juncture, owing to the fact that patents are pending, full details of the control unit cannot be published. However, it is possible to give an idea of the principle of operation of the device, which has an action similar to that of the limited-slip mechanisms incorporated in certain differentials. A diagrammatic illustration of the layout is in the next column. The pinion on the rear of

Table 1—PARTICULARS OF PRIMARY REDUCTION GEARS

Ratio	*Number of teeth*		*Diametral pitch*
	Input gear	*Output gear*	
1·133 : 1	15	17	5·98
1·187 : 1	16	19	6·54
1·266 : 1	15	19	6·35
1·33 : 1	15	20	6·54
1·412 : 1	17	24	7·66
1·474 : 1	19	28	8·78
1·563 : 1	16	25	7·66
1·647 : 1	17	28	8·4
1·722 : 1	18	31	9·15
1·842 : 1	19	35	10·1
1·933 : 1	15	29	8·22

Table 2—PARTICULARS OF GEARS AND PINIONS IN THE MAIN BOX

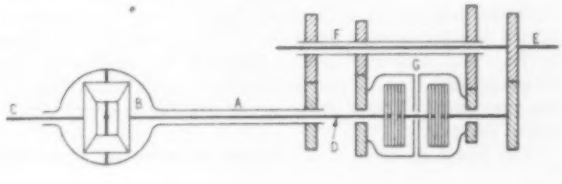
	Number of teeth	*Diametral pitch*
Input shaft—		
fifth	22	6·35
fourth	21	6·5
third	17	5·77
second	17	6·64
first	12	6·06
Output shaft—		
fifth	22	6·35
fourth	24	6·5
third	23	5·77
second	29	6·64
first	30	6·06
Reverse idler	31	12·7

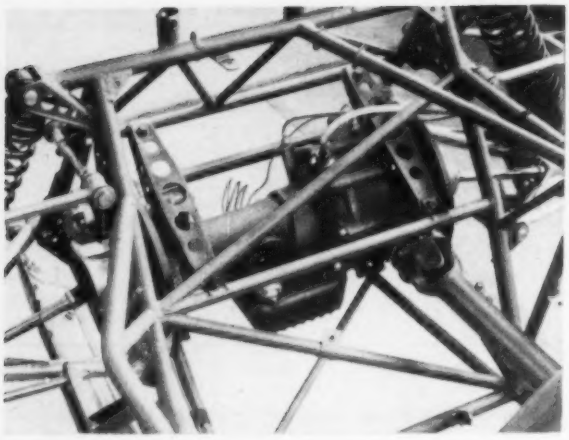
the gearbox output shaft is the same size as the gear with which it meshes on the sleeve member. Whereas the ratio between this member and one of the clutches just mentioned is greater than 1 : 1, that between the member and the other clutch is less than 1 : 1.

In the normal condition, when all four road wheels are revolving at the same speed, the third differential is not operating, since its two output shafts are in synchronism with each other and with the output shaft of the gearbox. The two clutches of the control unit are then both disengaged, so the casing of one is free to revolve more slowly, and that of the other more rapidly, than does the shaft that passes through the unit and drives the rear wheels. If either or both of the front wheels tends to spin, however, the cage of the third differential is accelerated, which results in a speeding-up of the gearbox output shaft, and therefore also of the sleeve member and the casings of the clutches. The speed difference between the faster running clutch and the shaft is consequently increased; when it exceeds a certain value, the clutch comes into engagement. In so doing, it not only limits the degree of wheelspin but also transfers

Diagrammatic layout of the third differential and the control unit

A *gearbox output shaft;* **B** *third differential;* **C** *propeller shaft driving front wheels;* **D** *intermediate shaft;* **E** *propeller shaft driving rear wheels;* **F** *sleeve member;* **G** *duplex clutch unit*





In this view of the rear final-drive unit, the finned oil sump is clearly visible, as are the breather pipe and the capillary tubes to the oil pressure and temperature gauges on the facia panel. The bolts of the upper mountings are carried by fabricated brackets bolted to the frame

some torque from the gearbox output shaft to the rear wheels, thereby removing the cause of the spin. Under wheel locking conditions, of course, the converse occurs, more negative torque being applied to the gripping wheels.

Should spin tend to occur at the rear wheels, the shaft passing through the control unit is accelerated; so too, by way of the third differential, are the gearbox output shaft and the sleeve member, but by half the amount. Consequently, the speed difference between the slower running clutch and its shaft is increased, so engagement of this clutch takes place when the limiting value of the wheelspin is exceeded. Torque is therefore transferred from the rear wheels to those at the front, and the spin is controlled as in the previous case. To compensate for the fact that the front wheels follow a longer path on corners than do the rear ones, a greater speed difference is tolerated by the front clutch than by the rear one.

Lubrication of the transmission assembly is very thorough. The casing embodies a sump containing five pints of oil, which is distributed by means of a gear type pump. This pump is driven by a quill shaft extending rearward from the torsionally resilient shaft between the engine clutch and the primary reduction. A jet of oil is directed at the meshing point of the gears of this reduction, but against the direction of rotation, to avoid the risk of hydraulic lock. The other gears are lubricated by radial drillings to their teeth, the oil being fed to the interior of the shafts. Additional drillings lead oil to the needle roller bearings of the gears on the output shaft of the gearbox; the various ball bearings are lubricated by splash. Since the level of the oil in the sump is below the lowest point of the gears, the temperature of the lubricant is kept low and power losses through churning are avoided. Instruments in the cockpit record the oil temperature and pressure.

Final-drive layout

Because both final-drive units are mounted on the sprung portion of the vehicle, the Hardy Spicer propeller shafts from the gearbox are of the fixed-length type. The diameter of the tubular portion of each is $1\frac{1}{2}$ in, the wall thickness is 16 s.w.g. and the lengths between the centres of the universal joints are $17\frac{7}{8}$ in for the front shaft and $28\frac{1}{2}$ in for the rear shaft. These joints are of the conventional needle roller design.

The equal division of the torque between the front and rear wheels enables the bevel type final-drive units to be of a common design. Because both propeller shafts are offset $6\frac{1}{2}$ in to the left of the car's longitudinal axis, however, the two units are both disposed with the pinion outboard of the crown wheel, which also is towards the left of the assembly. The pinion-carrying portion of the casing of one unit is rotated through 180 deg relative to that of the other, but so far as shape and detail design is concerned both are identical. To ensure the highest possible mechanical efficiency, the crown wheel and pinion have straight-cut teeth. It will be appreciated that the use of a primary reduction means a numerically smaller ratio in the final-drive units than would otherwise be needed; this smaller reduction results in a more robust crown wheel and also contributes to the attainment of a high efficiency and compactness.

Machined on the left-hand end of the main portion of the casing is a spigot, which enters the machined bore of the pinion-carrying portion. The two are secured together by a ring of eight $\frac{5}{16}$ in studs and nuts. Unusually, the pinion is not overhung: a very rigid assembly is obtained by mounting it in a special double-row ball bearing at the input side, and in a roller bearing at the other. The ball bearing has a single inner race but two outer races of the angular-contact type. Its bore, outside diameter and axial width are respectively 30 mm, 62 mm and $\frac{13}{32}$ in; the corresponding dimensions for the roller bearing are 15 mm, 42 mm and 13 mm.

The inner races of both bearings are pressed on to the integral shaft of the pinion, and are located against shoulders; the outer race of the roller unit is housed in the casing. In contrast, the outer races of the ball bearing are pressed into a steel housing of tubular form, with an in-turned flange at one end an an out-turned one at the other end. The first-mentioned flange serves as an abutment for the races, and the second as a means of attachment to the casing. Shims are fitted between the flange and the casing to adjust the mesh of the gears. The housing spigots into the opening in the casing and is secured by a ring of studs and nuts; the studs pass through the out-turned flange and through that of a second member, which houses the oil seal and forms the securing abutment for the races of the bearing.

Towards its input end, the pinion shaft is splined to accept a half-coupling, the flange of which is bolted to a corresponding flange on the universal joint yoke. These two flanges are mutually located by a spigot. The half coupling is retained on the shaft by a nut, and its end remote from the nut bears against the inner race of the ball bearing. Tightening of the nut therefore clamps the race against the shoulder on the shaft. The nut and the shaft are drilled to receive a driven-in locking pin: because the nut is recessed into a counterbore in the half-coupling, the walls of the latter are also drilled, to a larger diameter, to permit the insertion or removal of the pin.

The pinion and the crown wheel are both made of En.39B steel; they have 14 and 37 teeth respectively, giving a ratio of 2·643:1, and their mean diametral pitch is 7·575. A spigot locates the crown wheel on the cage of a four-pinion differential, which is almost identical with the third differential already described: although the torque input to each final-drive unit is half that to the third differential, this difference is more than made up by the multiplying effect of the final-drive reduction. The wheel is secured by a ring of eight $\frac{5}{16}$ in bolts.

A heavy-duty roller bearing carries the extended hub of the crown wheel. The rollers run directly on the ground surface of the hub and are guided by L-section circlips situated in circumferential grooves in the outer race, which is pressed into the casing and retained by a conventional

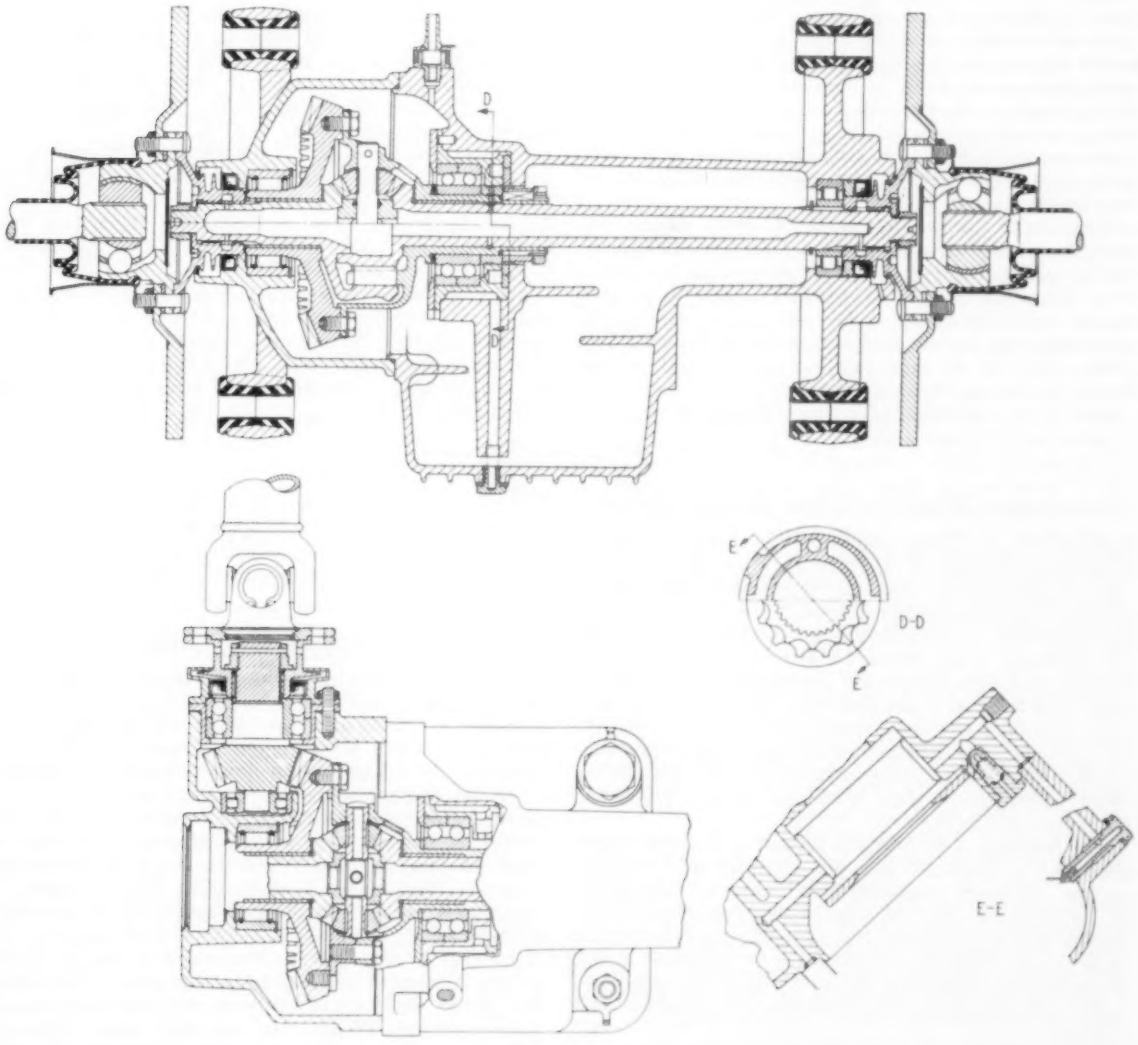
circlip. This bearing has an overall diameter of 62 mm, and the rollers are 7 mm diameter × 15 mm long.

To the right of the differential, the cage has a long, shouldered hub, on which is the inner race of a double-row ball bearing. This bearing is of the angular-contact type and is of a design similar to that on the pinion shaft, though it is of larger dimensions: the bore, outside diameter and width are respectively 35 mm, 72 mm and 1⅛ in. To adjust the meshing of the crown wheel, shims are fitted between the inner race and the shoulder on the cage.

The outer races of the ball bearing are pressed into a steel carrier, which in turn is a push fit in the bore of a boss in an intermediate wall in the main portion of the casing. There is a spigot portion at each end of the carrier, to ensure that it is firmly located in the bore, and at its left-hand end is an external flange that bears against the end face of the boss. The outer races of the bearing are retained in the carrier by an annulus; studs projecting from the boss secure both the annulus and the carrier. Housed in the boss, to the right of the bearing, is a Hobourn-Eaton eccentric-lobe oil pump, the rotor of which is mounted on the hub of the cage.

Steel to En.39B specification is again employed for all six gears of the differential. The hollow output shafts are integral with their gears, and that on the left—which is relatively short — runs within a steel-backed lead-bronze bush in the bore of the crown wheel. Outboard of the bush, this shaft is splined, and it terminates in a threaded portion of reduced diameter. On to this thread is screwed a nut that retains the adaptor, a KE 805 steel forging, to the flange of which is attached the input member of the inboard universal joint of the half-shaft; the brake disc, of which further details will be given in Part II of this article, is also mounted on this flange. An oil seal, housed in the casing outboard of the roller bearing, bears on the periphery of the adaptor, near its inner end. Immediately outboard of the seal are two flinger flanges, which supplement the seal in ensuring that the oil does not reach the brake disc.

The two final-drive units are identical except in respect of the positioning of the pinion-carrying portion on the main casing. In this illustration, the side elevation shows both the standard differential assembly, which was designed by Harry Ferguson Research Ltd, and an alternative ZF unit



A second lead-bronze bush carries the right-hand output shaft within the hub of the differential cage. At its right-hand end, this shaft runs in an orthodox roller bearing measuring $1 \times 2\frac{1}{4} \times \frac{3}{8}$ in, which is pressed into the casing from the outboard end; its outer race registers against a shoulder, but is not secured since it does not have to withstand axial loading. The shaft is a push fit through the inner race. Any tendency of the race to creep in an inboard direction is limited by a circlip assembled into a groove round the shaft. Movement in the other direction is prevented by the adaptor for the universal joint and the brake disc; this adaptor is identical with that at the other end of the assembly.

Each final-drive unit is resiliently attached to the chassis frame at four points, two at each side. All four mountings are arranged in a common vertical plane through the transverse axis of the unit, two being above the casing and two below it. The vertical spacing of the mountings is $8\frac{1}{2}$ in and their transverse separation is $13\frac{1}{4}$ in. Each mounting is in a boss at the end of an arm cast integrally with the casing, and is of the familiar type consisting of a flanged, two-piece, rubber bush and a steel inner sleeve.

Mention has already been made of the fact that an oil pump is embodied in the unit. The oil is contained in an integral, finned sump having a nominal capacity of three pints. From the pump, the oil travels along internal drillings to a jet that directs it at the point of mesh of the crown wheel and pinion, the subsequent distribution being by splash, with gravity return to the sump. As in the gearbox, the oil level is below the lowest point of the gears, so there are no churning losses. Oil passes through the bores of the shafts and radial drillings to the roller bearings at the ends of the unit. The pressure and temperature of the oil are recorded in the cockpit.

Although an insulating annulus is fitted between the brake discs and their adaptors, some heat flow back to the bearing seals at the ends of the final-drive units is unavoidable. Consequently, oil from within each shaft is fed to a cooling annulus adjacent to the seal. In the case of the right-hand seals it returns to the casing by way of a long spline, and from the other two it returns through various clearances and the bearings themselves.

Since cyclic variations in the speed of a road wheel could promote resonant vibrations as well as snatch, Birfield constant-velocity universal joints are employed at both ends of the half-shafts. These joints are basically of the 75AC type developed for the B.M.C. ADO 15 car and described in the April 1961 issue of *Automobile Engineer*, though naturally there are differences to suit the particular application. The inner members of both joints are mounted on the half-shafts; those of the inboard assemblies are a sliding fit on their driving splines—to provide the nominal length variation necessary even with the special Ferguson suspension, in which the lower wishbone and the half-shaft are of equal length—and those of the outboard joints are located by spring rings.

As previously stated, the outer or driving member of each inboard joint has a flange for attachment to the adaptor on the end of the output shaft of the differential. In the case of the outboard joint, the outer member is integral with the wheel spindle, which is splined and threaded to accept the wheel hub and its securing nut. The hub, which is clamped by the nut against a shoulder on the wheel spindle, runs in two opposed taper roller bearings. Since the hubs are of the fully floating type, there is no risk of a wheel coming off in the unlikely event of a half-shaft breaking.

At the rear, the hub bearings are housed directly in a carrier that forms a link between the upper and lower wishbones of the suspension system, to be described in Part II of this article. The hub bearings of the front wheels, however, because of the necessity of steering articulation, are carried in the outer member of a large ball joint, which contains the outboard universal joint. This ball joint, too, will be examined in detail in Part II.

The half-shafts are made of KE 805 steel, and their effective lengths, between the geometric centres of the universal joints, are $12\frac{5}{16}$ in at the rear and $13\frac{5}{16}$ in at the front. Because the braking torque at the front is higher than that at the rear, the front shafts have the larger diameter of 0·795 in, that of the others being $\frac{1}{8}$ in. The En.36 hub forgings are of generally similar design for both the front and the rear pairs of wheels, and a common bearing assembly has been adopted: the outboard bearing has a bore of $1\frac{1}{2}$ in, an outside diameter of $2\frac{5}{16}$ in and a width of 0·71 in, and the corresponding dimensions of the inboard item are $1\frac{1}{4}$ in, 2·33 in and $\frac{5}{8}$ in.

To be continued.

Amended Standard for Safety Glass

RECENTLY, an important amendment has been made to British Standard 857, *Safety glass for land transport*. The change concerns toughened glass windscreens, and its purpose is to afford improved forward visibility in the event of fracture and the consequent opacity of the screen. Under the provisions of the amended Standard, the manufacturers of toughened glass screens are permitted to incorporate in them what is called a modified zone, measuring about 16 in wide × 6 in deep and positioned in front of the driver. In this zone, the glass is toughened to a lesser degree than over the rest of the screen, so the particles formed on fracture are larger; consequently, their boundaries present less of an obstruction to vision.

The Standard is unaltered in respect of laminated safety glass, and of toughened glass for use other than in windscreens. Although toughened glass screens not embodying the modified zone are still permitted by B.S.857, the specification now sets a lower limit on the particle size, in addition to the upper limit already laid down. The object of this alteration is to ensure that failure of a uniformly toughened screen does not result in the formation of undesirably small particles.

Copies of the amendment, which has the designation PD4162, are available, price 1s 6d each, from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1. The price of B.S.857 itself is 3s 6d. Postage is charged extra to non-subscribers to the Institution.

Motor Transport Library

AT THE Montagu Motor Museum, Beaulieu, Hampshire, there is a library, the scope of which is now to be extended. Although at the present time it is not possible for the Museum to operate a lending service, there are facilities for inspection of material in the reading room. A photostat service is in operation for the benefit of enquirers who are unable to visit Beaulieu in person, and the librarian also undertakes research. In order to cover costs, a charge is made for photostats, and there may be a modest fee for research. The library is prepared to act, in respect of historical research, in an advisory capacity for motor manufacturers. It is stated that the Museum will keep its files entirely up to date, and the librarian is willing to handle queries relating to modern, as well as veteran, Edwardian and vintage cars. All enquiries should be addressed to the librarian, L. G. Firmin, The Montagu Motor Museum, Beaulieu, the telephone number of which is Beaulieu 734.

Lucas Electrical Developments

Immersed Fuel Pump, Motor-Driven Cooling Fan with Thermostatic Control, and Three-Blade Windscreen Wiper

The 2FP petrol pump, recently introduced by Joseph Lucas Ltd, has a continuously rotating impeller. Normally it is mounted on the floor in the tank, operating immersed in the fuel

BECAUSE of the high degree of standardization of electrical equipment for motor vehicles, it is indeed unusual for three new items to be introduced simultaneously on one car. All three—an immersed fuel pump, a thermostatically controlled engine cooling fan and a windscreen wiper with three blades—are produced by Joseph Lucas Ltd. and are fitted to the Jaguar E type vehicles. Reference was made to them in the brief analysis of the car, in the April 1961 issue of *Automobile Engineer,* but in view of their undoubted technical interest, a more detailed description is warranted.

2FP fuel pump

This pump was developed by Lucas primarily to obviate the vapour lock troubles now prevalent in fuel systems. Since vapour lock is obviously most likely to occur on the vacuum side of a fuel pump, the remedy consists of imparting a small gravitational pressure head to the incoming fuel. Normally, the unit is mounted on the floor of the tank, but an external low-level installation adjacent to the tank may also be practicable. Where the pump is in the tank, as on the Jaguar car, it is carried either in a small well or at the lowest point of the floor, if this is sloping. In this way, a pressure head is maintained even when the tank is almost empty. Internal baffling may be needed to prevent fuel surge away from the pump intake during acceleration, braking and cornering.

The pump is of the rotary impeller type and is driven at a nominal speed of 2,900 r.p.m. by a small electric motor. It delivers the fuel at a predetermined pressure, and that not required by the engine is recirculated, by way of a relief valve, to the inlet port. One of the accompanying illustrations shows the construction of the pump. The body and the top and bottom covers are pressure diecastings of zinc-base alloy, and the joint faces are sealed by synthetic rubber rings, housed in grooves in the body. Five set-screws secure the bottom cover, while the upper one is retained by two studs and self-locking nuts.

Within the body is a vertical, stainless steel shaft, on which are mounted the impeller and, above it, the armature of the electric motor. In the interest of simplicity and reliability, the motor has a high-energy permanent magnet field system, the two pole pieces of which are of the laminated type. Orthodox construction is employed for both the armature and the commutator. The laminated iron armature core is pressed on to serrations on the shaft, and security of the commutator segments is ensured by moulding them on to their insulating hub.

Carrying the shaft are two spherical bearings of moulded, plastics-impregnated fabric. The upper bearing is housed in the top cover, and the lower one is in the body, between the armature and the impeller. Both bearings are held in their part-spherical seatings by spring retaining plates. At the ends of the shaft, housed in the end covers, are thrust pads of the same material as the bearings. In cases where the pump is installed inside the tank, the electric cables pass through a petrol-proof gland into the tank, and thence through a plastics sheath terminating at a moulded nylon adaptor on the top cover of the pump.

A plastics impeller is employed, and it has radial grooves moulded in it to form the vanes. It floats on the shaft and is driven by a stainless steel peg, the ends of which project from a diametral hole in the shaft and register in slots in the impeller. The upper half of the toroidal chamber containing the working portion of the impeller is formed in the pump body and the lower half is in the bottom cover.

An unconventional feature of the pump is that the inlet port, instead of being at the eye of the impeller, is at the periphery, as is the delivery port. The internal galleries with which these ports communicate are in line and horizontal. To the outboard end of the inlet gallery is attached an intake unit embodying a flat, gauze filter element, the housing of which extends under the pump body; at the corresponding end of the delivery gallery is a union for the feed pipe to the engine.

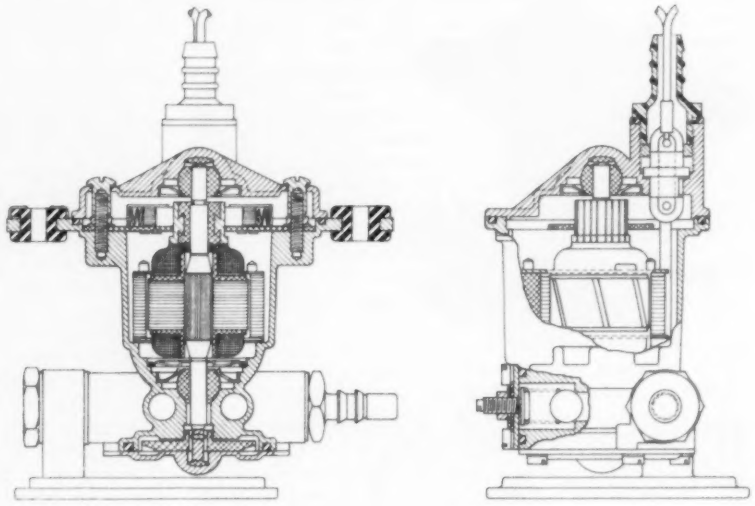
Because of the peripheral porting, the pump cannot accurately be described as a centrifugal unit. It is, in fact, referred to by Lucas as being of the cumulative type, because the pressure builds up progressively during the passage of the fuel from the inlet port, round the periphery of the impeller, to the outlet port. As a result of this feature of the design, the delivery pressure is claimed to be higher than it would be in the case of an equivalent pump of conventional centrifugal design. Between the delivery port and the outlet union is a relief valve of the spring-loaded ball type, the blow-off pressure of which is adjustable by means of a screw protruding through the body. Both the ball and the spring of the valve are of stainless steel, to avoid the risk of any variation in the setting owing to corrosion.

When the pump is operating, the whole of its interior is flooded with fuel. There is, in fact, a continuous circulation of fuel within the body, to avoid stagnation in the region of the motor bearings and brush gear. The fuel passes upward through the lower bearing of the armature into the motor chamber, and returns through an internal passage to the pump intake port.

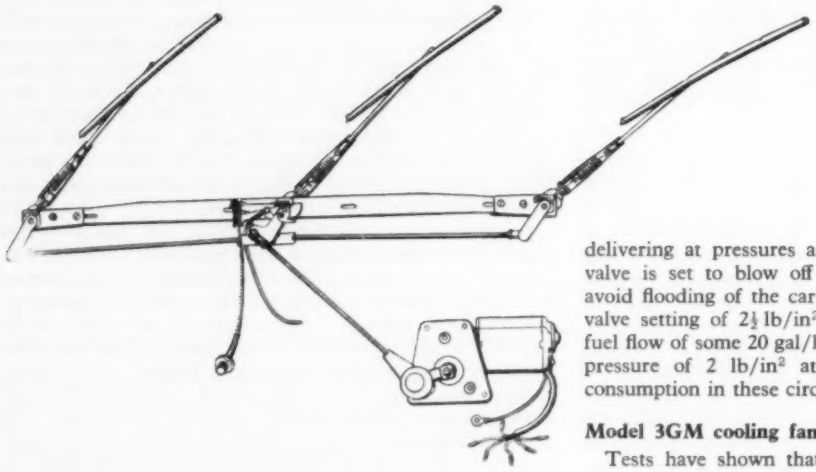
If the pump is to be installed inside the fuel tank, special provision is made for repriming it automatically should the tank be run out of fuel. This provision consists of a small bleed hole in the pump body, near the outlet port, through which fuel can enter the pump; during normal running, a small continuous discharge takes place through this hole. In the case of an external mounting, the pump is sited at a

level low enough for self-priming, so the bleed hole is not embodied.

According to the manufacturers, the risk of fire is negligible. Even if the fuel level in the tank should become so low that the motor chamber becomes empty, the vapour remaining therein would normally be too rich to ignite. The only ways of communication between the motor and the pump are through the bearing and the internal return passage; and since the nominal clearance in the bearing is small and the return passage has a high length : bore ratio, they form flame traps to prevent the spread of the fire in the extremely unlikely event of ignition of the mixture in the motor chamber. To cater for the remote contingency of the development of excessive bearing clearance, however, a gauze flame trap is incorporated between the armature and the bearing. As a final safeguard against fire, the base filter contains a 200 mesh element.



General arrangement of the 2FP fuel pump. The impeller is a plastics moulding and is driven by a peg that is carried in a hole in the shaft. An adjustable relief valve is incorporated, and its ball and spring are of stainless steel, to obviate any risk of failure owing to corrosion



The three blades of the Lucas DL3 windscreen wiper are connected by links to the crank arm on a two-speed electric motor. This layout was evolved specifically to ensure the effective wiping of wide but relatively shallow screens with a considerable transverse curvature

The pump has a two-point resilient mounting. Projecting horizontally from the top of the body casting are two ears, which are drilled to receive rubber grommets of the double-flange type; the attachment studs pass through these grommets, above and below which are fitted plain washers and nuts. This arrangement permits the height of an internally installed pump to be correctly set in relation to the bottom of the tank, and it provides a means of compressing the grommets by the desired amount. One of the grommets embodies an anti-static earthing washer for connection to the tank or, in the case of an externally mounted pump, to the vehicle structure.

The weight of the pump is 2¼ lb, and the makers quote the following performance figures. With a 12 V supply, that is, when the engine is switched off or idling, the maximum rate of fuel flow with an open delivery pipe is approximately 45 gal/hr. When the engine is running above the cutting-in speed of the generator, and the battery voltage is about 13·5 V, the delivery rate in the same conditions is over 50 gal/hr. While the pump is capable of delivering at pressures as high as about 5 lb/in² the relief valve is set to blow off at a lower pressure than this, to avoid flooding of the carburettor. In practice, with a relief valve setting of 2½ lb/in² and the higher battery voltage, a fuel flow of some 20 gal/hr is available—at an actual delivery pressure of 2 lb/in² at the float chamber. The power consumption in these circumstances is in the region of 20 W.

Model 3GM cooling fan

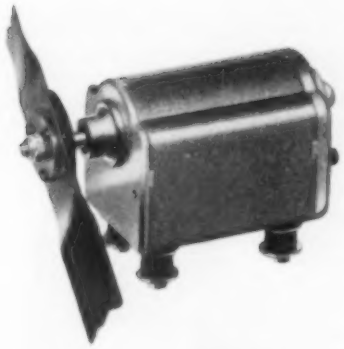
Tests have shown that, in average conditions of climate and traffic, the fan of a liquid-cooled engine may be really necessary for perhaps only 10 per cent of the total running time. It follows that a continuously running fan is fundamentally an inefficient device: not only does it consume power unnecessarily, and raise the noise level, but the resulting over-cooling has an adverse effect on the rate of warming-up, on the performance of heating equipment, and often on the fuel consumption. A temperature-sensitive system, which brings the fan into operation only when it is essential, is therefore of considerable potential benefit; the simplest layout of this type is probably that comprising an electrically driven fan controlled by a thermostat switch.

The Lucas 3GM fan system standardized on the Jaguar E type vehicles is of the kind just described, though it is not the first in this field. Production is facilitated by the use of a motor based on one employed in certain windscreen wiper installations; the current consumption of this unit is 6 to 7 A, over the normal speed range of 2,100 to 2,300 r.p.m.

A two-blade fan, the supply and installation of which are the customer's responsibility, is secured against a shoulder on the motor spindle by means of a stiff-nut. In the Jaguar installation, the fan is of pressed steel and has a diameter of 16 in; its blades are $1\frac{3}{8}$ in wide and are set at a pitch angle of 10 deg.

The thermostat, which is immersed at a convenient point in the cooling system, actuates a relay to switch the current to the fan on or off according to the temperature. To avoid hunting in certain circumstances, the thermostat is set to provide a differential of 20 deg C between the temperatures at which the relay opens and closes; the closing temperature is, of course, the higher. The transmission of vibrations from the engine and other sources is reduced by mounting the motor resiliently on the vehicle. Four holes are drilled in the carrier bracket or plate, and into them are fitted rubber grommets, through which pass four studs projecting from the base of the motor. There is a plain washer above and below each grommet, and the studs are shouldered to avoid over-compression of the rubber when the nuts are tightened.

Since the motor is vulnerable to water entering the cooling air intake, a splash-proof cowling is incorporated. Although in the Jaguar installation the fan assembly is mounted behind the radiator, in the conventional position, there is no reason why it should not be of the pusher type if the particular layout makes this preferable. The unit, complete with the Jaguar fan but without the cowling, weighs 4 lb.



Since over-cooling of the engine can result in inefficiency, the Lucas 3GM fan shown here is switched off, when not required, by a thermostat switch

Model DL3 windscreen wiper

This new equipment incorporates a powerful two-speed self-parking motor, connected by link transmission to the spindles of the wiping arms. Although it can be used with two blades, it was developed specially as a three-blade unit for cars with wide, shallow screens of relatively large curvature, on which no two-blade system can provide really effective clearing, particularly at high speeds. To cater for the curvature as well as the rake of the screen, the spindles of the outboard blades are inclined outward and upward at a compound angle.

Mounted on the driving end of the motor, which is of orthodox design, is a gearbox comprising a two-start worm and a plastics worm wheel; the output shaft of the gearbox carries the conventional crank arm. A coupling of the eccentric type connects this arm to one end of the primary link or rod. The other end of the primary link is attached to the drop arm of the central wiper blade by a snap-back ball joint that permits rapid disconnection for removal of the motor unit. Secondary links connect this drop arm to those of the two outboard blades.

When the control switch is moved from the on to the off position, the direction of rotation of the armature is reversed. In this circumstance, the eccentric coupling rotates, thus altering the effective length of the primary link. Consequently, the locus of travel of the central drop arm is modified, causing all three arms to move to their parked position against the windscreen frame. This movement results in the actuation of a cut-out switch by the central arm, so the motor comes to rest. Under the bonnet is an adjuster for accurately setting the parking position of the blades.

The slow and fast speeds of the motor are equivalent to 45 to 50 c/min and 60 to 70 c/min respectively. When the motor is operating at its lower speed, the current consumption varies between $2\frac{1}{2}$ and 4A, according to the wetness of the screen; at the higher speed, the field current—and hence the total consumption—is approximately $\frac{1}{2}$A less. A thermostatic switch is incorporated to protect the motor against overloading. In view of the great importance of efficient screen wiping on fast cars, it is to be hoped that Jaguar Cars Ltd. will not be alone in adopting this unit.

Pliable Masking Tape

WITH orthodox masking tapes, it is sometimes difficult to follow a chosen line on surfaces with compound curves of small radius. A new product, of which the base material is crimped paper, is claimed to be sufficiently flexible to obviate this difficulty. This new pressure-sensitive adhesive masking tape, named "Tesakrepp", is manufactured by Metemicals (Cannon) Ltd., 60 Cheapside, London, E.C.2.

There are three grades of tape in the Tesakrepp range. The first, type 322, is the standard grade, which is able to resist temperatures up to 175 deg F, and which has extreme stretch quality. Type 323, which is elastic but not to the same degree as 322, is moisture-proof and able to withstand temperatures up to 212 deg F; it is recommended for operations involving wet sanding, spray painting and exposure to infra-red baking ovens. The third is type 324, which also is not as elastic as 322, is treated to withstand temperatures up to 280 deg F and to be immune from the effects of moisture, varnishes and their solvents.

It is stated by the manufacturers that a 60-yard roll of type 322 Tesakrepp will stretch to 80 yards, and they recommend that the tape should, in fact, be stretched before application. An adhesive strength of 1 lb/in² is also claimed for the tape, together with clean stripping properties and provision of a sharp colour edge. The tape is supplied in widths varying from $\frac{3}{8}$ in to 4 in, of which those in the range $\frac{5}{8}$ in to 2 in are in stock, while the remainder must be specially ordered. Each roll contains 60 yards of the tape.

Tesakrepp masking tape can be used to follow curves of small radius

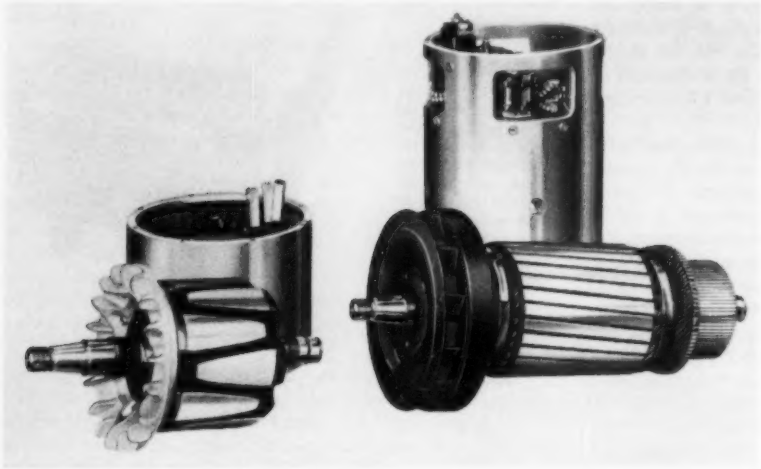


Fig. 2. A comparison between an a.c. machine, left, and a normal d.c. dynamo for the same duty. Both compactness and the absence of a commutator in the a.c. machine are important inherent advantages

ALTERNATORS FOR VEHICLES

General Principles and Design Considerations

By W. D. SUTHERLAND,* B.Sc., Ph.D., A.M.I.E.E.

SINCE the initial application of d.c. generators in the early part of the century, there has been little change in the systems used in the transport vehicle industry. Performances have increased, and better detail design has given improved efficiency and increased reliability, but the basic electrical limitations of the d.c. machine have remained.

During this period, the electrical loading of vehicle generating systems has steadily increased as a result of improved standards of comfort and vehicle safety. For example, a bus of the 1920s had a total electrical load of 150 W, as compared with 1,000 W for its modern counterpart. In addition, the increased congestion of roads, especially in and around large cities, has impeded traffic flow to such an extent that the majority of the operating time of the vehicle may occur with the engine running at idling speed.

In Fig. 1 is shown a typical curve illustrating distribution of engine speed in terms of total operating time, for a typical public service vehicle in city service. It should be noted that, for 35 per cent of the time, the engine is running at idling speed. This condition is obtained when the average speed over the route is in the 12 to 14 m.p.h. range. Any reduction in this average will increase further the time spent by the generator in the low speed range. The combination of low speed and increased loading has led to the development of a system of generation that will ensure that the electric loading requirement is met by the generator and, in addition, will enable the battery to be maintained in a satisfactory state of charge.

Although the problem outlined is mainly associated with road vehicles, an analogous condition occurs in the railway field, in particular on diesel-engined railcars on relatively short routes, where there are fairly long standing periods at intermediate and terminal stations. In these circumstances, engine idling conditions are obtained for long periods, often in excess of 60 per cent of total running time. With the conventional d.c. generator, which gives no output at idling, batteries tend to go flat. So in this application there is also a need for an improved electrical generation system.

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As a result of a study of both road and rail applications, it was concluded that, since the majority of existing d.c. dynamos were operating at the limit of their speed and output range consistent with adequate life, increased performance could be obtained only by increasing the size of the present dynamo range. This was unacceptable because of both the severe installational problems that would have arisen and the inevitable weight increase. Obviously, a system was required that would enable the copper and iron of the conventional d.c. machine to be more effectively used to produce electric power.

Electric generators share with other rotating energy-converters the ability to give, within their normal operating ranges, increases in output approximately proportional to speed. Hence, for a minimum size machine, it is clearly an advantage to run at the highest possible speed. Limitations are, however, imposed by the ability of the rotating parts to withstand centrifugal forces, the loading of the drive arrangements—particularly in the case of belt drives—the bearings in the machine and the commutation at the brushes.

For a conventional d.c. generator, a speed range of four to one can normally be accepted: beyond this range, the limitation is in respect of the commutation of the output current in the rotating armature. As all know, during the passage of each commutator segment beneath a brush, an armature coil is transferred from one current path in the armature to another having an opposite direction of current: the complete reversals of current occur while the coil is short circuited by the brush, but electromagnetic voltages generated in the coil by self- and mutual-induction oppose the change in current. These combined voltages, referred to as reactance voltages, are the basic cause of sparking at the brushes, which can give rapid brush wear and high temperatures.

Since this reactance voltage is proportional to speed and output current, the effects of commutation limit the maximum speed and output of the d.c. generator. In addition, a square-law relationship between the reactance voltage and the number of conductors in each armature slot places a restriction on low speed output. The smaller the number

of armature conductors the higher is the cutting-speed, that is, the generator speed at which the output voltage just exceeds that of the battery being charged. This speed is, of course, the value at which charging begins.

Commutation can be improved by the use of interpoles placed between the main exciting poles of the d.c. machine. The function of these is to suppress the effects of reactance voltage. They do not contribute directly to the output of the machine and, because of space limitations, their use is usually restricted to the larger sizes of machines.

The a.c. system

Omission of the commutator, in its conventional form, from a generator design enables the machine to be designed for high outputs at low speeds without any restriction on speed range. This can be done by using an a.c. current generating system. As is well known, in the conventional d.c. machine, the actual power is generated as alternating current, but, by the action of the commutator, this is rectified to d.c. In the alternator, the power is generated in a similar manner, but the action of the rotating commutator and brushes is replaced by the static commutating device, or rectifier. This enables the a.c. generator output to be maintained over a speed range wider than d.c. counterparts.

In the alternator, the pole pieces and field coils form the rotating assembly, or rotor, and only the field current is conducted to the rotor by brushes and slip rings. This current is usually about 1-2 A and, since the slip ring forms a continuous contact with the brush, there is no current change at the rubbing surfaces between the brush and slip ring. Therefore, the field current can be conducted without arcing, even at very high speeds. The windings in which the current is produced are assembled in slots in the stationary yoke, or stator, which is the electrical equivalent of the rotating armature in the d.c. machine. With the stationary generating winding, the alternating current is brought directly to the terminals of the machine, Fig. 2.

For given operating conditions, the permissible output is limited by the temperature rise of the machine and, in particular, of the generating windings. In the d.c. machines, these windings are, in practice, joined to the commutator by soldering, which also sets the limit in respect of the safe temperature level. On the a.c. machine they are on the stator, and form part of a larger volume and mass than the comparable armature of the d.c. machine. This enables it to be designed to give adequate output at lower speeds than the corresponding d.c. machines and still to be capable of operating at high speeds. The top speed of the alternator is then limited by mechanical considerations relative to bearings and centrifugal forces on the rotor.

An alternator of given size can be manufactured with any one of a variety of stator windings, depending on the particular load requirement and the available drive speed range. For example, if a high drive ratio is available, a winding giving a considerable increase in output, relative to that of the d.c. counterpart, can be used. Alternatively, for an existing drive installation, the stator winding can be chosen to give additional output at lower speeds than previously obtained. This type of winding is particularly attractive for conversion of d.c. installations to a.c.

Design factors

So far as electrical design factors are concerned, the alternator can be driven at high speeds, and its size can be reduced as its operating speed is increased. Since the generated voltage is a function of the speed, the number of conductors in the stator winding and the magnetic flux linking these windings, any of these items may be varied to obtain the desired output. In commercial vehicle practice, however, the drive ratio is limited by the maximum permissible speeds for commercially available belts and the sizes of the pulleys used. Other forms of drive are, of course, possible, but in the United Kingdom, belt drives are widely used, and it is normal practice to limit peripheral speeds to below 6,000 ft/min. This gives a maximum ratio of 3:1 for most commercial applications, but another factor must also be taken into account: in view of the very rapid acceleration and deceleration possible with modern diesel engines, additional forces are imposed on the belts because of the torques demanded for the alternator rotor. In practice, ratios up to 2·8:1 have been used but, so far, the majority of applications have been with ratios of the order of 2·3:1.

The alternator is unaffected by direction of rotation and field polarity. This feature is of special importance in axle driven units for railway applications, where conventional d.c. generators require brush gear capable of being moved to enable the generator to operate in both directions of rotation. For public service vehicles, the physical size of an alternator of given maximum output is determined by the designed cutting-in speed, and is found to be approximately half that of an equivalent d.c. generator for the same duty.

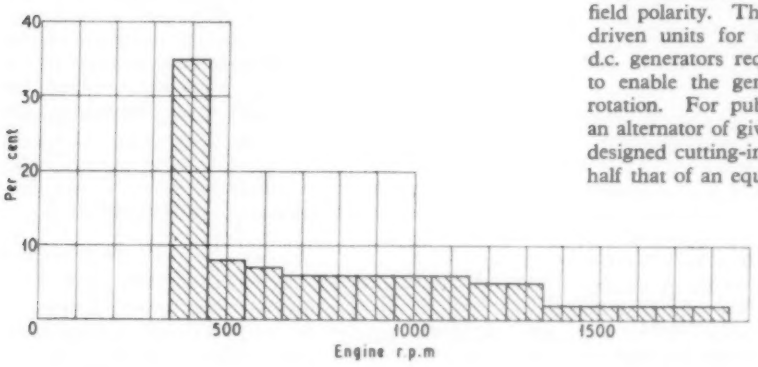
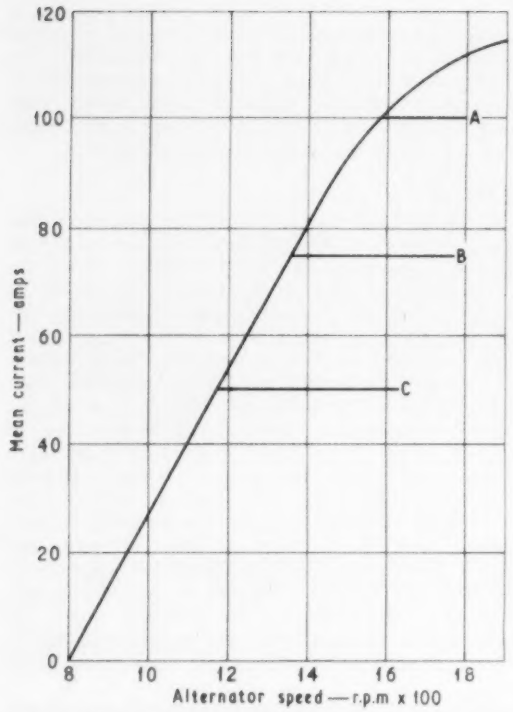


Fig. 1. This diagram illustrates a typical distribution, of engine speed, in terms of total operating time for a public service vehicle employed on a large city bus route

In an alternator, the number of output turns can be substantially increased, relative to that of a d.c. machine, without fear of obtaining a high reactance and subsequent commutation difficulties; also, the flux can be kept fairly small. The size of alternator required to obtain a desired cutting-in speed will, therefore, be minimal, since the maximum advantage can be taken of the dependence of voltage upon output turns and speed. Further economies in machine size can be made by permitting higher electrical loadings and operating at higher temperatures. With a totally enclosed machine, the maximum theoretical output cannot be successfully attained because of temperature limitations and hence, if a machine of the minimum size is required, ventilation must be provided in order to avoid the design restrictions that are imposed by these thermal limitations.

The maximum temperature of a d.c. machine is limited by the softening of the solder and the danger of its being thrown by centrifugal force. Since the output windings of an a.c. machine are stationary, only connections between coils are required, and these can, if necessary, be brazed. In totally enclosed machines the maximum permissible winding temperature is often restricted to a level low



A *output, through-ventilated:* **B** *output, surface-ventilated;* **C** *output, unventilated*

Fig. 3. Effect of ventilation on the output characteristics of an a.c. generator; through-ventilation can enable output to be doubled

enough to prevent conducted heat producing in the bearing housing temperatures in excess of those permissible for the high melting point greases used.

It follows, therefore, that change in output can be effected merely by altering the mode of ventilation. Illustrated in Fig. 3 are the output characteristics when a given machine is operated totally enclosed, surface ventilated and through ventilated. Increases of 50 and 100 per cent can be accommodated, with all components, except the end shields, identical. This would not be possible with a d.c. generator, because an increase in output would necessitate the employment of larger brushes, commutator and possibly other components.

Mechanical problems associated with the ventilation of alternators are easily overcome. In the d.c. machine, the commutator and brushes suffer most from the entry of dust and other foreign matter, and there is no practical method of enclosing the commutator while ventilating the remainder of the armature. In the alternator, this enclosure is readily achieved by placing the slip rings and brushes in a compartment outside the ventilated body of the machine. In the type of alternator chosen for vehicle applications, the spacings between the rotor fingers form good natural passages for ventilation.

In its simplest form, the a.c. machine is termed a single-phase unit and, as shown in Fig. 4, an output voltage is obtained whose polarity is alternatively positive and negative during each revolution of the rotor. From the schematic diagram, it can be seen that if additional phase windings are fitted to the machine, increased use will be made of the available rotor flux. It can be shown that, for a given size of frame, by using a three-phase winding arrangement, an increase in output of 50 per cent can be obtained. A further increase in number of phases causes a slight increase in output, but in machines having the outputs required for vehicle applications, the extra winding and rectification complication is not justified. The output curve for a three-phase machine is also shown in Fig. 4. Rectification of the negative half cycles of the generated voltage waves is, of course, necessary if this output is to be used for battery charging during normal operation of the vehicle.

Types of alternator

In the study to determine the most suitable type of alternator for public service application, three basic types were considered, namely the inductor alternator, salient pole and imbricated pole machines. The permanent magnet type was not considered since, without the introduction of expensive components and control systems, it cannot provide the high specific output and close regulation required for vehicles. The three types that were considered are

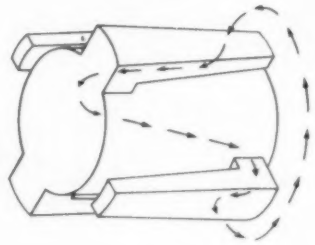
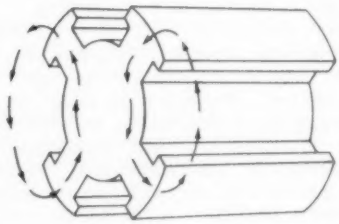


Fig. 6, right: Magnetic circuits of the imbricated and salient pole types of alternators, shows respectively top and bottom



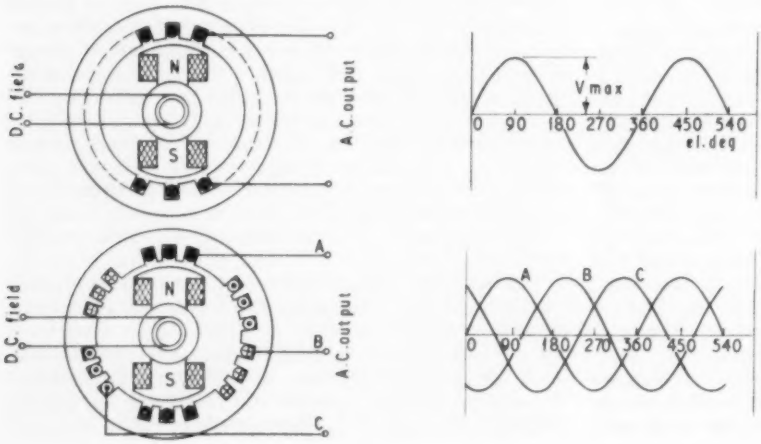


Fig. 4. Single-phase and three-phase alternator wiring diagrams and wave forms. An increase in output of 50 per cent can be obtained by using a three-phase instead of single-phase winding in this type of machine

illustrated in Fig. 5, which is in the middle of this page.

It might appear that the inductor alternator, which has both stator and rotor windings on the stator, and therefore has no slip rings, is attractive. Unfortunately, however, its flux path is such that only half the voltage is produced from a given quantity of iron, as compared with that from the excited rotor type of construction. The flux in the inductor alternator does not reverse from maximum positive to maximum negative, but changes only from zero to maximum: this was considered a serious disadvantage and precluded its consideration for commercially competitive machines.

The choice between salient and imbricated pole designs is not so obvious, but as a result of design calculations on both, the imbricated pole type was chosen. In it, a single field coil, carrying a current of approximately a quarter of the corresponding salient pole design, is used to provide field excitation in the rotor: this enables conventional vibrating contact voltage regulators to be retained. The magnetic circuits of these machines are shown in Fig. 6. In the imbricated pole design, the magnetic circuit consists of as many parallel paths as there are poles, the rotor core being

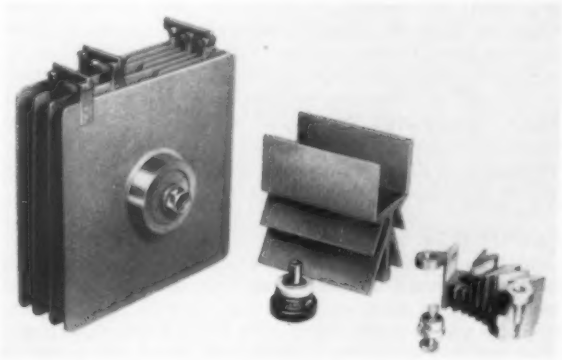
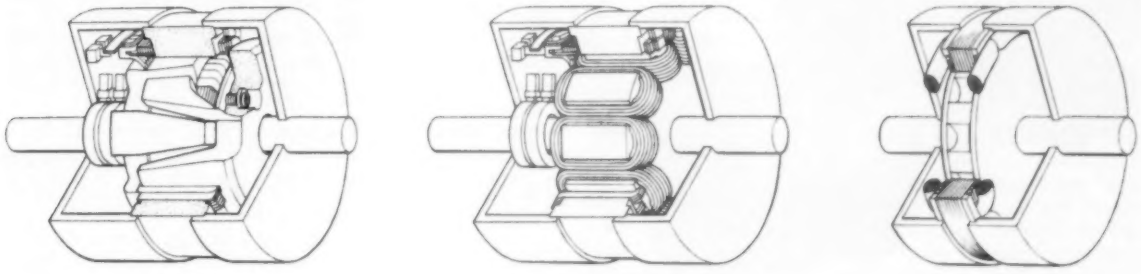


Fig. 8, above: Silicon, germanium and selenium rectifiers compared

Fig. 5, below: Differences between three types of alternators: left, imbricated pole; centre, salient pole; right, inductor alternator



common to all paths. The core assembly is constructed from three parts: these are a tubular core shrunk on the shaft and two identical rotor claws, which are either cast or forged. The complete construction is, therefore, extremely robust and suitable for high-speed operation.

The rectifiers

A rectifier is, of course, an integral part of any alternator system and, being a static component, requires no attention, as compared with the commutator it replaces. As mentioned earlier, the alternator is wound for three-phase operation and, therefore, to obtain the optimum value of d.c. current, a three-phase full-wave unit comprising six or multiples of six rectifier cells is used. The basic system of connecting these with the alternator is shown in Fig. 7.

Semi-conductor rectifiers are universally used for vehicle applications. This is because their compact crystalline junctions are extremely strong mechanically and are resistant to shock and vibration. Three materials, selenium, germanium and silicon are employed, Figs. 8 and 9, the choice depending on ambient temperature, cooling arrangements, space available and initial cost.

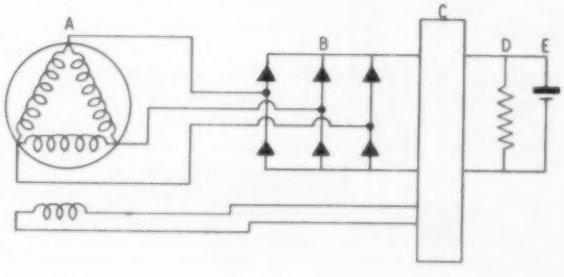
Selenium, which has been used for many years, has a relatively low peak inverse voltage, 42 V, a low current density, a relatively low maximum junction temperature, 80 deg C, and is subject to a degree of ageing, that is, alteration of characteristic with time. Its bulkier design, however, gives a higher heat capacity and enables it to withstand overload conditions of voltage, current and temperature for short periods without suffering permanent damage. The efficiency of this type of unit, 95 per cent, is the lowest of the three but, at the present time, its cost is also lowest.

Germanium and silicon rectifiers have been introduced in recent years and are gradually replacing selenium ones. Both can operate at higher current densities and both have higher peak inverse voltages and efficiencies, up to 98 per cent for germanium. Although silicon can withstand temperatures up to 150 deg C, the limit for germanium is 65 deg C, and the rectifying characteristics of both types are destroyed whenever rated operating conditions are exceeded. The cost of a germanium unit is still almost twice that of the equivalent selenium one, but with the further development of the silicon rectifier, the germanium type will probably be completely replaced by it in this field.

Because of the high permissible temperature of the silicon unit, the rectifier elements can be mounted directly on the alternator end shield, where cooling can be obtained from the alternator fan. With this arrangement, the machine has all the advantages of an a.c. generator and yet, as is the case with a d.c. machine, is directly connected to the battery: this obviates the need for cables—which can be lengthy—between the generator and rectifier.

The reliability of semi-conductor units is largely depen-

Fig. 7. Simplified diagram of the connections for a.c. equipment
A *alternator;* **B** *rectifier;* **C** *control board;* **D** *load;* **E** *battery*



dent upon the method of production and, especially, the ability to keep the junction materials immaculately clean and free from foreign matter. For instance, any moisture or soldering flux left inside during manufacture, or entering as a result of imperfect encapsulation, can cause sudden failure. Fortunately, these dangers have been well known to manufacturers for a considerable time and, as volume of production of these devices increases, the possibility of these defects occurring will be even further reduced.

Applications

In diesel railcars, the rectified a.c. charging system has been widely used in recent years and, since these cars are mainly used on suburban services and branch lines, frequent stopping and long periods of slow running are encountered. The introduction of the engine-driven alternator system in power cars has resulted in batteries being kept in a satisfactory state of charge. In these applications, germanium rectifiers have been widely used, but it is envisaged that the silicon type will eventually be applied in this field.

In the motor vehicle field, the alternator has been successfully introduced where mobile radio transmitter-receiver installations are carried, and the consequent extra load on the battery demands greater charging capacity. The types of vehicles that have this equipment are fire engines, taxi cabs, police cars and ambulances, and they almost invariably spend a large proportion of their operational time at low speeds or simply standing by. Adequate output under idling conditions is, therefore, a prime requirement for them.

Regarding public service vehicles, a broad case for the employment of generators that give an output at idling has already been made, but this can be further illustrated by considering specific installations and the performance of the alternators that C.A.V. Ltd. have currently in production. The present standard d.c. generator for public service vehicles is 7 in diameter, has an output of 55 A and 24 V, and can be driven at ratios of up to 2·3:1. When this output curve is compared with the speed-time analysis plot, Fig. 10, it can be seen that negligible output is obtained under idling conditions. If this machine is replaced by the 7 in diameter alternator, the increase in output at idling is such that even under idling conditions, a large percentage of the electrical load of the vehicle is now supplied by the alternator.

This alternator is designed for 24 V systems and has a self-limiting output of 60 A at 27·5 V. Its cutting-in speed is 580 r.p.m. and, with a drive ratio of 2·3:1, its output at

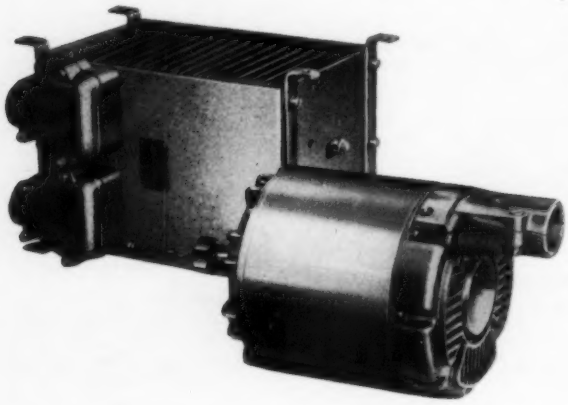


Fig. 11, above: Selenium rectifier assembly together with a 7 in diameter a.c. generator

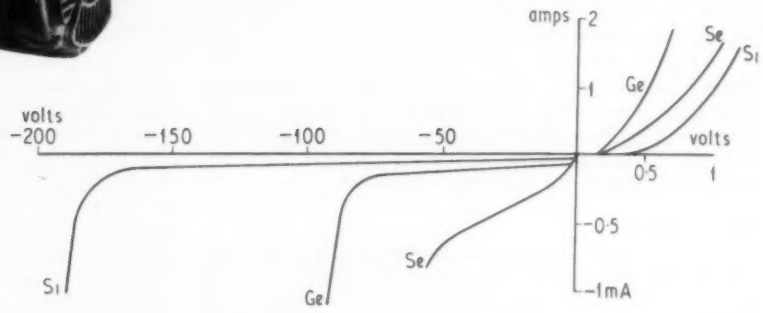


Fig. 9, right: This diagram shows the characteristics that are typical of silicon, germanium and selenium types of rectifier

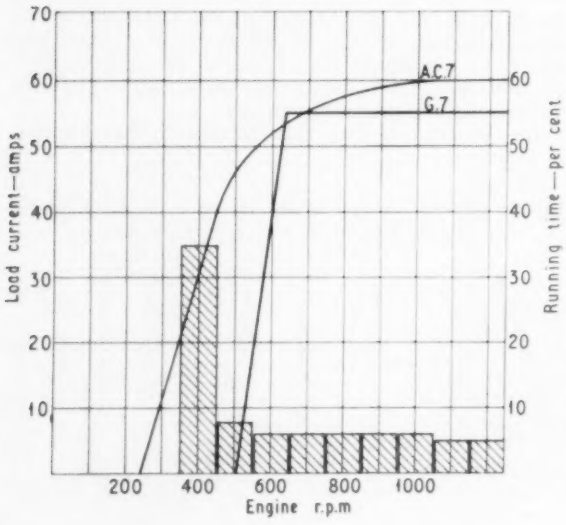


Fig. 10, below: Performance curves of the a.c. 7 in and d.c. 7 in generators superimposed on the speed time analysis of Fig. 1

normal idling speeds of 350-400 r.p.m, is from 19-29·5 A. If the drive ratio is increased to 2·5:1, the output at the same speeds will be from 25-30 A. Ventilation of the machine is effected by a built-in fan, which directs cooling air through the interior of the machine. The slip rings are not subjected to high temperatures, and therefore are enclosed within the end shield of the generator: this protects them from moisture, oil mist and road grit.

Both machines are 7 in diameter and hence, in the case of cradle-mounted installations, their space requirements are similar, but the weight of the alternator is only 37½ lb, as compared with the 84 lb of the original d.c. machine. In installations where the load is well balanced and the battery kept in a high state of charge, it is possible to consider a reduction in battery capacity, except in certain instances where the battery size has been chosen to meet a particular cold starting requirement. If a smaller battery can be used, the savings in respect of its initial cost and that of carrying battery dead weight are not inconsiderable. For example, a 145 lb saving in weight could be translated into a £4 17s 0d saving in fuel, over 50,000 miles, per year.

At the present, the C.A.V. 7 in alternator is available

with a selenium rectifier as a separate unit, and the basic weight comparison is:

(1) 7 in d.c. generator	84 lb
(2) (a) 7 in a.c. generator	37½ lb
(b) Selenium rectifier	20 lb
Total, a.c. system	57½ lb
Saving in weight	26½ lb

The separate rectifier unit is of the selenium dry plate type. Its elements are housed in a robust metal box, which is open at the top and bottom to permit a natural flow of air through it, for cooling. The rectifier is designed for operation in ambient temperatures of up to 35 deg C without the need for forced cooling. Where the rectifier has to be operated or housed in conditions of higher temperatures, some form of forced cooling is required. The main rectifier assembly, Fig. 11, also includes an auxiliary rectifier for operating the subsidiary circuits such as that for field isolation to prevent the battery from discharging when the alternator is stationary.

Housing of silicon diodes within the machine is the next logical step, and many prototype machines having this layout are currently in service. Assembly of the silicon diodes, mentioned earlier, within the end shield of the machine is illustrated in Fig. 12. With this arrangement, the weight comparison is:

(1) 7 in d.c. generator	84 lb
(2) 7 in a.c. generator with built-in diodes	38 lb
Saving in weight	46 lb

Control board

Alternative types of control board are available for this type of generating set: one is fitted with a conventional vibrating contact type and the other a transistorized type regulator. In principle, a regulator is, of course, a device that compares the voltage or current being regulated with some reference quantity, the excess or deficiency being fed back in such a manner as to correct the original error.

The conventional vibrating contact voltage regulator is essentially a relay, in which the electro-magnetic operating force proportional to the generator voltage is balanced against a reference force exerted by a spring. When the voltage exceeds the preset value, the operating force is greater than the spring force, and the relay pulls-in, cutting the generator field current. Consequently, the generator voltage falls so that the relay drops out, remaking the field current. This make and break action occurs some hundreds of times a second and maintains the voltage constantly at its preset value.

As a result of this contact action, wear inevitably occurs. This leads to a very gradual change of the regulated voltage, and so it is sometimes necessary to reset the regulator. In addition, it has been found that, on 24 V circuits, field currents in excess of 2 A cannot be reliably carried by the contacts so, in cases where larger field currents are required, twin regulators have been used. Contact arcing, due to the making and breaking of the inductive current of the generator field circuit, causes some radio interference.

Transistors, since they have no wear problem or practical limit in respect of current capacity, are most suitable for use in regulators. An additional advantage is the virtual absence of radio interference. As is now fairly well known, the transistor is an electrical device formed by joining two p-n junctions, or rectifiers, back to back. The result is a three-terminal device that can be used, with suitable circuit connections, to give current and power gains from electrical input signals. So far as general characteristics are concerned, the transistor resembles the pentode thermionic valve. A limitation of the transistor is the voltage that can be applied across it. For instance, germanium power transistors now available are limited to a maximum of about

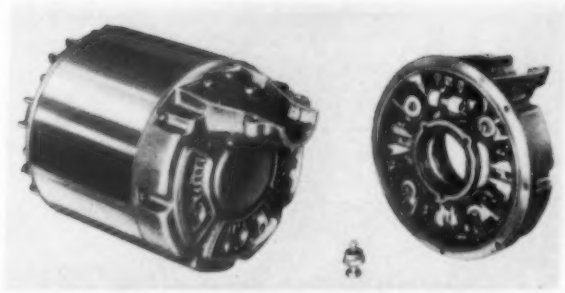


Fig. 12. This a.c. generator with built-in diodes is 19½ lb lighter than a similar unit having a separate selenium rectifier assembly

60 V. As in the case of the germanium rectifier, temperature limitations also apply, although for silicon transistors these limiting values are slightly higher.

The life of a transistor is difficult to determine positively, since there are no moving parts that might be subject to wear. Transistor manufacturers sometimes mention the figure of 10^6 hours as an average life. Failure rates are, at this stage, difficult to predict, but one manufacturer recently published figures indicating a failure rate of 0·02 per cent per thousand hours, based on experience with 21,000 transistors over three years. This confirms earlier evidence: correctly used, transistors can have very low failure rates.

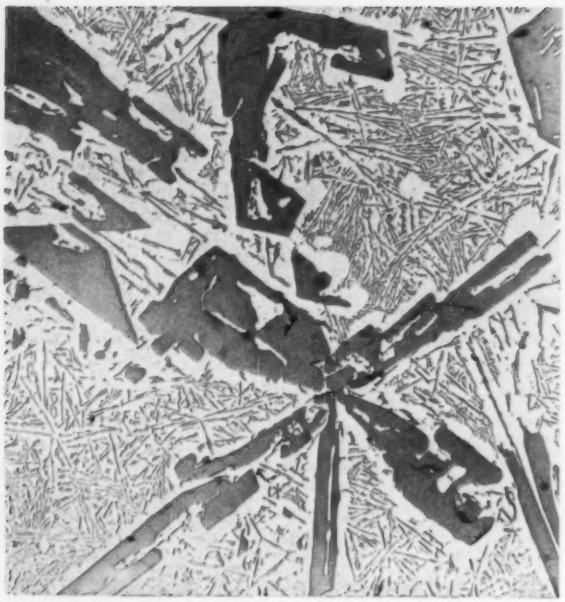
In the C.A.V. transistor regulator for the alternator, a Zener diode reference source is used for comparison with the generated voltage, and a transistor trigger circuit, which is either conducting or non-conducting, is controlled by the Zener circuit. Initially, the generator voltage is low and no current flows in the Zener diode, a condition which allows the full field current to pass through the main transistor, which is in series with the field circuit. When the generator voltage rises, and current flows through the Zener diode, the transistor switch circuit is triggered and the main transistor presents a high resistance in the field circuit, thus reducing the field current and, consequently, the generator voltage. This, in turn, alters the Zener diode current and the circuit is triggered to the full field current condition. This cycle is continuously repeated and holds the voltage constant.

The setting of the transistorized regulator is subject to very little drift with change in ambient temperature or with age. This type is, therefore, particularly suitable for applications in which the generator is operating for long periods at constant speed, where difficulties are sometimes encountered with the conventional contact type regulator.

Control boards available for use in conjunction with the alternator also carry an isolating relay, which is introduced to ensure that when the generator is at rest the field circuit is automatically disconnected from the battery circuit. The relay also serves as an isolating switch, for disconnecting the charging system from the battery. This unit should not be confused with the conventional cut-out used on d.c. installations. In the alternator application, the relay does not make or break the load current, and so its contacts are not subjected to the arcing obtained with conventional d.c. generator cut-outs.

From the foregoing, it can be seen that the alternator system comprises a 7 in machine, a selenium rectifier and a regulator, either transistorized or vibrating contact. With this system, the advantages relative to the original d.c. installation can be summarized as follows:

(1) More output at low speeds
(2) Less weight of installation
(3) Less servicing, because there is not any commutator
(4) Possibility of reduction in battery capacity required.



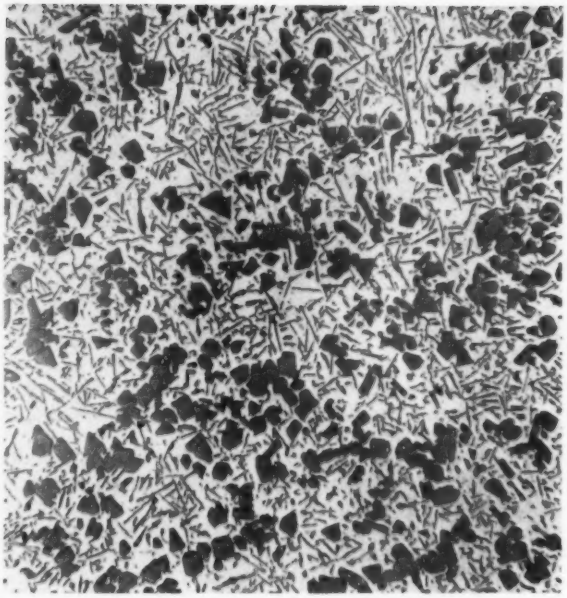


Fig. 1, left: Large silicon crystals in an unrefined, cast aluminium alloy containing 22 per cent of silicon—magnification factor 55. Fig. 2, right: The refined structure obtained by adding a small amount of phosphorus to the same alloy before it is cast—again at a magnification factor of 55

Aluminium for Cylinder Blocks

Some Relevant Metallurgical and Foundry Aspects

By J. R. HALL, B.Sc., A.R.S.M.

AMONG the most obvious advantages of aluminium alloys for motor car engines are their lightness and high thermal conductivity. As compared with cast iron, they are only about a third as heavy, and their conductivity is three times as great. For these reasons, aluminium alloys have been used for many years for cylinder blocks in certain high duty engines, such as those for aircraft and sports cars.

Although, for the mass-produced car, economic considerations have until recently ruled out the aluminium engine, this position is now changing, for there are several new American production models with aluminium alloy blocks. These blocks are being made as gravity die castings, low pressure die castings or ordinary pressure die castings—processes which allow the component to be made to very close dimensional tolerances, so that subsequent machining is reduced to a minimum. This is one great production advantage aluminium alloys have relative to cast iron, and it makes them economically attractive despite the higher cost of the metal. With cast iron, the metal temperatures are too high to allow the use of these precise methods of casting, in which iron or steel moulds are employed. Instead, iron castings have to be made in sand moulds, so close dimensional tolerances are not easily achieved and there is little scope for eliminating machining operations.

High silicon alloys

In the motor car engines now in production, because the cylinder bores are lined, usually with cast iron, the fullest advantage is not being taken of the physical properties of aluminium. The use of liners reduces the possible weight saving and sacrifices some of the benefit that might be obtained in respect of the high thermal conductivity of aluminium. It is a practice that has been adopted, however, because the aluminium alloys used have not the requisite wear resistance. A further step forward would undoubtedly be the development of an aluminium alloy sufficiently wear-resistant to be used, for a cylinder block, without lining the bores. Aluminium alloys with a high silicon content seem to be capable of fulfilling this requirement.

These alloys have been known for some time, but they have only recently aroused interest in this country. They contain 18 to 30 per cent of silicon, and their basic structure is somewhat similar to that of many bearing alloys, such as phosphor bronze, in that it consists of hard, wear-resistant particles embedded in a relatively soft matrix. In this case, the hard particles are crystals of silicon and are embedded in a matrix consisting of a fine, intimate mixture of silicon and the much softer aluminium. Because of this unusual structure, these alloys have exceptionally good wear resistance and there is already some evidence from American sources that it may be possible to use them in an engine without liners.

Another important advantage is that, for an aluminium alloy, they have quite a low coefficient of thermal expansion —a characteristic which is an important consideration in engine design. Because alloys of this type have received little attention so far, less is known about casting them than is the case with the more conventional aluminium alloys. Slightly different techniques are required and these have recently been studied in the research laboratories of the British Non-Ferrous Metals Research Association.

Refinement of structure

As has already been mentioned, silicon appears in the structure of the casting in two forms—as isolated crystals of silicon and as small needles in a fine intimate mixture of aluminium and silicon forming the matrix of the alloy. Without a special refining treatment, the isolated silicon

crystals can grow to a large size, as shown in Fig. 1, and the mechanical properties of the alloy are adversely affected. The coarse silicon also makes machining difficult and may cause scoring of rubbing parts.

It is, however, relatively easy, by adding a small amount of phosphorus to the metal before casting, to refine the structure so that the silicon crystals are small and well dispersed. While the precise mechanism of the action of phosphorus is not known, it is thought to form nuclei on which the crystals of silicon can grow, so that many small crystals are formed instead of relatively few large ones. The structure of a properly refined alloy is shown on the opposite page, in Fig. 2.

In the work carried out by the B.N.F.M.R.A. a thorough investigation has been made into the refining treatment; the various ways of adding the phosphorus have been assessed; and the optimum phosphorus content to give the best mechanical properties determined. The effect of phosphorus on particle size and tensile strength is shown in Fig. 3. Sufficient tests have been made to establish without doubt that a production foundry could achieve consistent refinement of the structure even if the metal is kept molten for two to three hours, for example, in feeding a die casting machine.

Silicon is even lighter than aluminium, and so these are among the lightest of the aluminium alloys. The low density of the silicon, however, causes one difficulty: unless the metal freezes rapidly, the silicon crystals tend to float towards the top of the casting. This effect is illustrated in Fig. 4. In production castings, which would be made by gravity or pressure die casting, this segregation of the silicon would not arise, because the metal is frozen so quickly; but it is noticeable in castings over half an inch thick made in sand moulds. This is an important point to be borne in mind in connection with prototype components, which often have to be made as sand castings to avoid the expense of making metal dies at that stage of the project. Unless special steps are taken to avoid this silicon segregation, such prototype castings may not have the required structure and could easily give misleading results on test.

Pressure die casting

If these high silicon alloys become extensively used by the motor industry, castings will undoubtedly be made by pressure die casting, to give the highest possible rates of production, close dimensional tolerances and a sound, dense structure. As is well known, in this process the metal is cast in a steel die which is split into two parts that can be closed or opened hydraulically. The molten alloy is injected into this steel die under high pressure and freezes almost instantaneously.

High silicon alloys have a higher melting temperature than the aluminium alloys normally used for pressure die casting, but die casting trials have been carried out with the co-operation of a member firm of the Research Association and no major difficulties have been encountered. In fact, the trials were most successful, and while some changes may be necessary in the usual pressure die casting practice, there is no obvious reason why first class castings should not be made in normal quantity production runs.

Alloy development

The basic aluminium silicon alloys of the structure shown in Fig. 2 can be varied considerably by altering the silicon content in the range 18 to 30 per cent and by making other additions such as copper, magnesium and nickel. Several alloys are at present being tested in the laboratory to find out which will be most suitable for engines. The tests include long term measurements of dimensional stability at engine temperatures, evaluation of the machining characteristics of the alloys, and also wear tests. The last-mentioned work presents considerable difficulties as no laboratory wear test yet discovered truly reproduces the conditions that obtain in service. There is no doubt that a real evaluation of the possibilities of these alloys can come only from engine trials, and sufficient research work on the foundry characteristics and properties has now been carried out to enable satisfactory prototype castings to be made for such tests.

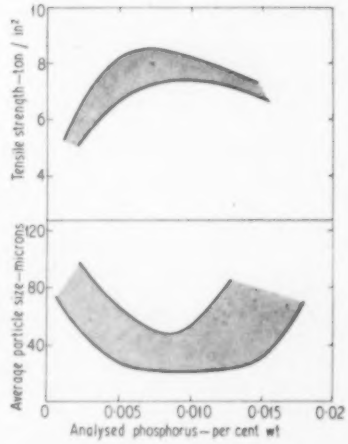


Fig. 3. Curves showing the effect of phosphorus content on tensile strength and average size of silicon particles in 1 in diameter chilled bars of an aluminium alloy the silicon content of which is nominally 22 per cent

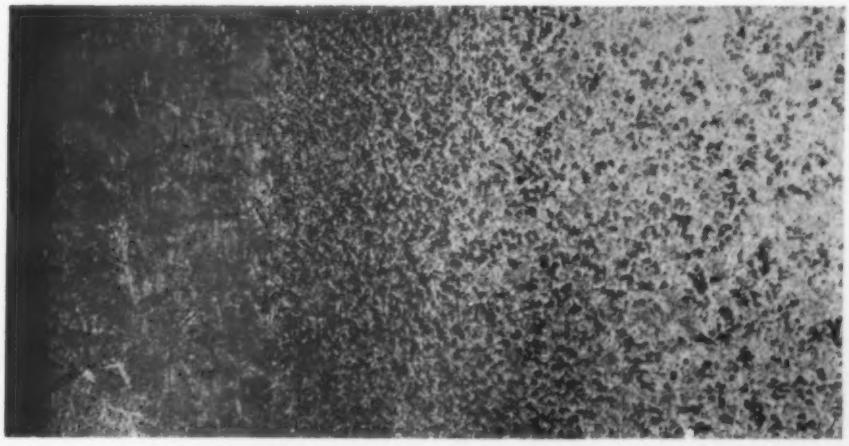


Fig. 4. Unless the casting freezes rapidly, the silicon crystals tend to float towards the top. This illustration shows segregation in a 1½ in thick, sand cast block—at a magnification factor of 5

BOOKS

Brief Comments on Recent Foreign Publications

that are of Interest to Automobile Engineers

Kräfte in Einrichtungen zur Verbindung von Kraftfahzeugen mit Zweiachsanhängern bis 20 Km/hr Höchstgeschwindigkeit (*Forces in Devices Connecting Motor Vehicles with Four-Wheel Trailers at Maximum Speeds not exceeding 20 km/hr*). Deutsche Kraftfahrtforschung und Strassenverkehrstechnik No. 141.

In German, by O. Bode, Prof. Dr. Ing. and R. W. Heinemann, Dipl. Ing.

Düsseldorf: VDI-Verlag G.m.b.H. 1960. 11¾×8¼. 22 pp. Price DM.16.80.

Widespread use of trailers in Europe and many other overseas countries has caused the attention of transport authorities and vehicle builders to be focused on the mechanical problems encountered with the couplings. A clear understanding of the operating conditions is essential for the formulation of economic designs, if costly failures or breakdowns are to be avoided, however arduous the service.

The assessment and significance of the forces imposed on the coupling were considered in a previous report, number 140, so the report now under review deals only with forces encountered under varying operating conditions and at speeds not exceeding 20 m.p.h. After dealing with the test programme, the authors describe the vehicles, couplings, road and test equipment and deal with the method of test evaluation and the results obtained.

These results are of general interest as far as they go, but it might have been profitable to have provided a more general assessment and evaluation of the entire coupling problem rather than present it virtually on an instalment basis. The present report is already the sixth by Prof. Bode and his co-authors on this subject—the others are numbers 112, 113, 114, 119, 140, and there is one by Prof. Essers, number 124—and no doubt others are to follow. This piece-by piece method of publication of the latest developments, as they occur, will be of help to a small circle who are likely in any case to benefit from normal circulation of the reports, whilst designers and operators at large would be more likely to prefer a comprehensive approach to such an important problem, which they are likely to be faced with in their work.

Kräfte in Einrichtungen zur Verbindung von Kraftfahrzeugen mit Einachsanhängern bis 20 Km/h Höchstgeschwindigkeit (*Forces in Coupling Devices for Motor Vehicles and Single-Axle Trailers at Speeds up to 20 k.p.h.*). Deutsche Kraftfahrtforschung und Strassenverkehrstechnik No. 140.

In German, by Otto Bode, Prof. Dr. Ing, Heinrich Meyer, Dipl-Ing, and Rudolf Walter Heinemann, Dipl-Ing.

Düsseldorf: VDI-Verlag G.m.b.H. 1960. 11¾×8¼. 23 pp. Price DM.16.20.

Dynamic forces likely to be encountered in service in the couplings of tractors pulling two-wheel trailers on roads or across country are not yet fully understood. Safety of operation is involved since the stability of the vehicle can be influenced to a considerable extent by the presence of vertical forces at the point of trailer attachment. These factors led to the carrying out of tests, at the request of the Federal Ministry of Transport, at the Motor Vehicle Institute of the Technical High School, Hanover, to determine the forces encountered, in the three principal planes, at couplings. These tests were made with agricultural tractors of three different makes and a road tractor, each pulling a two-wheel trailer weighing 1 ton and carrying a load of 3·5 tons. The results of extensive tests on good and bad roads as well as on a cart track are considered in terms of the influence of static vertical loads, coupling gear characteristics, and road speeds under steady conditions, starting, accelerating and braking. The presentation of the data and the conclusions arrived at as the result of extensive testing of different vehicles on a strictly comparative basis will be of interest and assistance to designers of tractors and trailers.

Untersuchung und Entwicklung von Bremsen zur Verbesserung und Sicherung der Bremsfähigkeit im Geschwindigkeitsbereich von mehr als 110 km/hr (*Investigation and Development of Brakes to Improve and Increase Safety of Braking in a Speed Range in Excess of 110 km/hr*). Deutsche Kraftfahrtforschung und Strassenverkehrstechnik, No. 139.

In German, by G. Müller, Dr. Ing.

Düsseldorf: VDI-Verlag G.m.b.H. 1960. 11¾×8¼. 24 pp. Price DM.16.20.

This report deals with road tests carried out to determine the effectiveness of the brakes of production vehicles incorporating hydraulic servo systems. First, the author briefly considers the heat problems concerned, the test equipment and methods used. Then he gives the test results, obtained with various types of drum and disc brakes, with particular reference to brake temperatures when bringing the vehicles to standstill as well as when running them continuously on a drum test rig.

The author's conclusions are comprehensive and should be of particular interest to vehicle and brake designers. Whilst a report of this type is not intended as a comprehensive treatise on such a complex subject, it is one of many interesting contributions which all add up to impart a clearer understanding and a better appreciation of a technical problem of ever-increasing importance.

Zusammenstellung von greifbaren Unterlagen über die Bedeutung des Reifenluftdruckes und der Reifenkonstruktion für die Strassenschonung and Wirtschftlichkeit des Verkehrs (*Summary of Available Information on the Importance of Tyre Pressure and Design on Road Preservation and the Economics of Traffic*). Deutsche Kraftfahrtforschung und Strassenverkehrstechnik, No. 137.

In German, by W. Kamm, Prof. Dr. Ing. and W. Koennecke, Dr. Ing.

Düsseldorf: VDI-Verlag G.m.b.H. 1960. 11¾×8¼. 47 pp. Price DM.27.90.

Increasing road traffic, heavier loads and smaller wheels all tend to increase the wear and tear of the roads, thus adversely affecting the overall economics of road transport. That the tyre characteristics can be of great importance, in this respect, has been established by numerous workers who have given their results and conclusions in a still wider range of publications. Appreciating that tyre pressures and construction can have a marked influence on road life, the German Ministry of Transport has entrusted the Battelle Institute with the evaluation on the basis of already published information, of the importance of the tyre design parameters. The report under review is the result of a study of one American and 72 German papers; it deals with the main factors, under the headings, static ground pressure, pressure distribution on the road, tyre stiffness and damping, dynamic wheel and ground pressures, vehicle speed, horizontal forces and directional stability, adhesion between wheel and road, rolling resistance, tyre wear, road destruction, and finally, the main features of tyre construction. Each chapter comprises extracts and illustrations from the relevant papers, skilfully presented to provide a clear and valuable collection of useful data of great utility to tyre and vehicle designers as well as to road engineers, transport operators and economists. The overall effect of the major variables is briefly considered in the conclusions of this clear and useful summary of the current position in this important field.

Weiterentwicklung von Friktionswerkstoffen (*Further Development of Friction Plastics Materials*). Forschungsbericht des Landes Nordrhein-Westfalen, No. 849.

In German, by Direktor Ludwig Martin and Ing. Friedrich Steiner

Köln und Opladen:
Cologne: WESTDEUTSCHER VERLAG, 1960. 11¾×8¼. 66 pp. Price DM.20.50.

This is a report dealing with some development work that has been done with friction materials, on a powder metallurgy basis. Detailed research and tests were made with the following aims: first, the determination of suitable mixtures of rubbing, or friction, materials and carriers; secondly, the finding of fracture resistant bonding agents to secure these materials to their steel backing plates, and then to prove these bonding agents by further tests and metallographic research; and thirdly, the development of economical methods of production.

The research on the behaviour of these friction materials in use was effected by a wide variety of tests. It has been found that, for the determination of the friction values, stick-and-slip moments and idling moments, it is essential to choose test rigs adequately representative of the actual conditions and layout of the equipment in which the material is to be used in practice, otherwise misleading results may be obtained. The author, in this report, has brought to light new knowledge and test results which should be a reliable guide and of practical use to engineers who design and manufacture heavy machinery, vehicles, brakes, clutches and transmissions of all kinds and for all applications.

Modified B.M.C. Sports Cars

DURING the past six weeks, the British Motor Corporation has announced improved versions of the existing Austin-Healey and M.G. sports cars, and also an extension of the range. The new model is, in effect a more luxurious version of the Austin-Healey Sprite Mark 2, which itself differs considerably from the Mark 1 model both mechanically and in respect of the bodywork. Minor styling changes have been made to both the Austin-Healey 3000 and the MGA, and these two models also incorporate mechanical alterations, which have resulted in an increased performance.

In the case of the Sprite, although the unitary underframe structure is little different from before, the appearance of the body has been modernized. The headlamps are now carried in the front wings, in the conventional manner, instead of being mounted in nacelles on the bonnet, and the treatment of the rear wings and radiator grille is more angular. Convenience has been enhanced by the provision of a boot lid: formerly, access to the boot was gained by tilting the seats forward. The front wings are an integral part of the body shell, whereas on the earlier model they formed part of the hinged bonnet assembly. As a result of these modifications, the weight of the car has increased by 59 lb.

The compression ratio of the B.M.C. 948 cm³ Series A engine has been raised from 8·3 : 1 to 9 : 1, by the use of different pistons, and larger inlet valves are employed and their opening period has been increased. S.U. HS2 carburettors with 1¼ in throttle barrels are now fitted, in place of the 1⅛ in H1 instruments formerly used; each carries a Cooper paper element air filter, whereas the pancake type with a metallic element was specified on the Mark 1 car. These alterations have raised the net power output from 42·5 b.h.p. at 5,000 r.p.m. to 46·4 b.h.p. at 5,500 r.p.m. The maximum torque has risen from just over 50 lb-ft to 53 lb-ft, but the speed at which it occurs has, surprisingly but commendably, been reduced from 3,300 to 2,750 r.p.m. According to the manufacturers, this double advantage is derived from the modifications to the camshaft, and to the gas flow characteristics of the head.

Because of the increased output and better torque characteristics, it has been found practicable to standardize the close-ratio gear clusters previously fitted only for competition purposes. The new ratios are 1 : 1, 1·357 : 1, 1·916 : 1 and 3·2 : 1, with a reverse of 4·114 : 1, whereas those of the Mark 1 Sprite were 1 : 1, 1·412 : 1, 2·374 : 1 and 3·627 : 1, reverse being 4·66 : 1. There is no change to the final-drive ratio of 4·22 : 1.

On the B.M.C. 2,912 cm³ Series C engine of the Austin-Healey 3000, a change has been made from the two S.U. HS6 carburettors, with 1¾ in throttle barrels, to three 1½ in HS4 instruments. The camshaft has been redesigned, to increase the lift of the inlet valves and the open dwell of the exhaust valves. In consequence of these changes, the net power output has risen from 124 b.h.p. at 4,600 r.p.m. to 132 b.h.p. at 4,750 r.p.m; the maximum torque of 167 lb-ft is unchanged, but it now occurs at 3,000 r.p.m. instead of 2,700 r.p.m. At a later date, vacuum servo assistance for the disc and drum braking system will be available as an optional extra.

In 1959, the swept volume of the Series B two-carburettor engine of the MGA was enlarged from 1,489 to 1,588 cm³, by increasing the bore from 73·025 mm to 75·4 mm. For the Mark 2 model recently introduced, the bore has been further enlarged to 76·2 mm, again without alteration to the stroke of 88·9 mm, so the swept volume has become 1,622 cm³. The compression ratio, too, has been increased from 8·3 : 1 to 8·9 : 1, larger valves are employed and the porting has been improved.

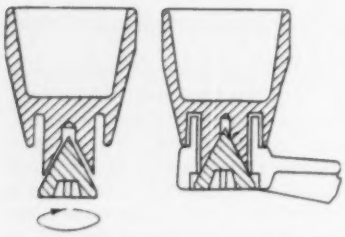
As would be expected, a substantial improvement in both the power output and the torque has been obtained by virtue of these two modifications. Whereas the maximum net figures for the 1,588 cm³ unit were 79·5 b.h.p. at 5,600 r.p.m. and 87 lb-ft at 4,000 r.p.m. respectively, the corresponding ones for the bored-out version with the 8·9 : 1 compression ratio are 90 b.h.p. at 5,500 r.p.m. and 97·4 lb-ft at 4,000 r.p.m. The rear axle ratio has been raised by almost 5 per cent to 4·1 : 1, thereby increasing the road speed per 1,000 r.p.m. in top gear from 17·2 to just over 18 m.p.h. No change has been made to the gearbox ratios.

Drilling Carbon Steels

TESTS to determine the effect of point shape on drill life, when drilling various ferrous materials, are being carried by the Production Engineering Research Association, of Melton Mowbray, Leicestershire. Previous reports in this series have covered the drilling of titanium alloy, Ti 150A, and drilling cast iron. The latest, Report No. 50, is entitled "Drilling Carbon Steels".

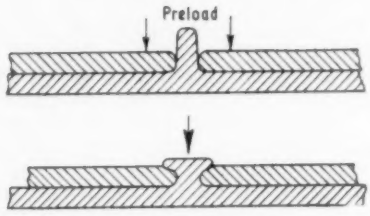
Detailed information is given in the report, which covers about 20 pages. The recommendations are as follows: when drilling En.3A steel the point angle should be 110 deg, and when drilling En.10 steel it should be 100 deg. The relief angle should be 12 ±2 deg for both. If mixed batches of low and medium carbon steel are to be drilled, it is suggested that a point angle of 100 to 105 deg be used.

Materials Now Becoming Available Afford Greater Scope for Rapid Assembly and Finishing Operations



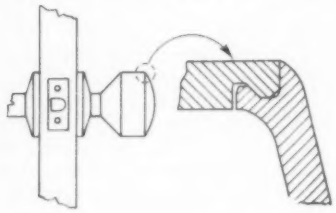
Above: This window-winder knob is in two parts. Enough heat is generated by one part spinning against the other to weld them together into a single, strong unit

Right: A thin-wall plastics container formed by spin welding two parts together. The faces that are to be welded together should be of stepped, grooved or vee configuration



Cold-heading and hot-heading operations make it possible to join components of either similar or dissimilar materials with equal facility

With a snap fit, the components, once they are assembled, are relatively unstressed, and the joint is unaffected by the passage of time



Methods of Assembly with Plastics

INCREASINGLY large sums of money are being spent on research directed towards the development of new plastics materials. Of those currently available, some are of value because of their appearance, some because of their functional uses and some for both. In general, their most important characteristics are low density and ease of forming, especially as compared with metals, although they have yet to be developed to the stage where they will compete in respect of strength, hardness and toughness with the metals used in modern road vehicles.

Ease of forming, which is the most attractive feature, is not always accompanied by amenability to the finishing and assembly operations that may be required subsequent to moulding. Among the factors that make such operations difficult or uneconomic are brittleness, temperature instability, poor machinability and resistance to metallizing or other types of finishing. Any material with few or none of these shortcomings would obviously help to reduce production costs.

At the 16th Annual Technical Conference of the Society of Plastics Engineers, held in Chicago last year, a paper was read by Mr. R. L. Miller, of E. I. duPont de Nemours & Co. Inc. It was entitled "Post-moulding Operations on Acetal Resin" and dealt with some of the processes now possible with plastics in the acetal resin group. The duPont company has introduced a thermoplastic material named "Delrin" which comes under this classification, and which is described as a highly crystalline, stable form of polymerized formaldehyde. By virtue of the properties of this acetal resin, it is suitable for assembly and finishing operations such as machining, welding and mechanical joining; spin-welding is a process to which it is particularly well suited, because of its fast setting rate after local melting has occurred.

Two typical examples of spin-welding techniques are illustrated: the first is for the fitting of a knob to a window winder handle, and the second is for the joining of the halves of a thin-wall container. In a spin-welding operation, one component is rotated at high speed while pressed against the other, and the resultant frictional heat melts a thin film of material at the joint. Rotation is then stopped and the two parts are held together under pressure while the weld solidifies. The end faces to be joined should have stepped, vee and tongue configurations, as illustrated.

The spin welding operation is a very short one, occupying only a few seconds. Slots or holes must, of course, be provided in the moulding so that the driving member can register in them and transmit its torque, and the stationary component can be held firmly in its fixture. With acetal resin, which has a melting point of approximately 350 deg F, a contact pressure at the joint of approximately 400 lb/in^2 is required; the average peripheral rubbing speed should be about 20 ft/sec, although higher rates can be used if shorter cycle times are needed. Unlike many other thermoplastic materials, this one can be stripped of its weld flash without recourse to cutting or machining.

In order to prevent shearing of the weld immediately after it has been formed, it is essential to halt the spinning component as rapidly as possible. Therefore, provision of a braked motor or quick release device is obligatory. Two methods of spin welding are suggested: in one, the driving tool is lowered on to the movable component which is already in contact with its mating part; in the other, the inertia method, the movable component is already spinning when the two parts are brought together under high pressure. In this second method, an adjustable slipping clutch incorporated in the driving head enables the component to come to a stop instantaneously when the friction in the joint is of sufficient magnitude, and appropriate proportion of the momentum of the head has been dissipated as heat.

There is a wide latitude in the choice of other welding methods that can be employed. Integral bonding of two mouldings of acetal resin can be accomplished by welding with a heated metal surface, and by the use of hot gas or hot wire. In the case of the first of these methods, the two mating faces are first held against a metal surface heated to between 445 and 555 deg F, the exact value of the temperature depending on the desired heating time and the size of the components. The two parts are then held together during the time it takes the weld to become permanent.

In this type of weld, only minimal pressure is necessary between the parts being welded. If the flash spreads more than $\frac{1}{16}$ in from the edge of the weld during heating or joining, it is evidence that excessive pressure is being applied: a pressure light enough to ensure contact is sufficient. Butt and sleeve joints are among the types possible with this method. Weld strengths of up to 80 per cent of that of the parent material are claimed.

For the joining of large components, hot gas welding may be used, but the disadvantages of this method are the time necessary and the skill required of the operator. A welding rod of $\frac{1}{16}$ in diameter is used, in conjunction with nitrogen at a temperature of 630 deg F, and the parts to be welded are rigidly held in fixtures. The use of hot air in place of nitrogen introduces the danger of oxidizing the molten resin, but if air is used, it should always be at a temperature of approximately 570 deg F.

Welding with hot wire is probably the simplest and neatest method, as the necessary equipment is inexpensive and there is no flash formed. A wire is clamped between the two faces to be joined, and a current is passed through the wire; sufficient heat is then generated to melt the resin and form a permanent joint. This method is suitable for complex shapes, and is simplified by the presence of a moulded-in groove for retaining the wire.

One of the advantages of acetal resins is that they are amenable to both cold- and hot-heading techniques, which, among other things, facilitate the joining of dissimilar materials. At 73 deg F the compressive yield stress is 17,000 lb/in^2, and preheating is not absolutely necessary. However, heading pressures are greatly reduced if heat is applied through the medium of either the peening head or a jet of air heated to 400 to 500 deg F.

Among the assembly processes not requiring the application of heat are interference fitting, snap fitting, cementing and the conventional fixing processes, in which self-tapping screws or nails are used. Good creep resistance and the retention of strength at high temperatures make acetal resins ideal for joints involving interference fits with components of either similar or dissimilar material; such joints are effective at temperatures of up to 300 deg F. As an example, the case can be quoted of a sleeve pressed on to a $\frac{1}{4}$ in diameter rod with a diametral interference of 0·009 in. The parting force of this joint, after it had been subjected to a temperature of 200 deg F for 1,000 hours, decreased by only 150 lb from 400 lb.

In one of the illustrations is shown a snap joint. This type of assembly method has the advantage that the parts, once assembled, are relatively unstressed, and the strength of the joint is not affected by the lapse of time. However, snap fits cannot in general be relied upon for other than decorative functions, because the degree of undercut possible is limited by ejection difficulties during moulding.

Strong nailed joints are a feasible proposition by virtue of the high compressive stress of acetal resin. These joints are best made with sharply pointed nails driven in by a very sharp blow. The holding power of a No. 17 wire nail in $\frac{1}{4}$ in thick sheet is approximately 110 lb.

Since acetal resin has excellent machining properties, it follows that, as well as being amenable to drilling and tapping, it is suitable for self-tapping screws. Fine threads are recommended for maximum strip strength and vibration resistance, and the optimum hole diameter for a screw is essentially the pitch diameter. Thread-cutting rather than thread-forming screws should be used, as the first-mentioned type produces excessive strain in the boss.

There are several commercial adhesives that can be used for bonding acetal resins, but joints made with them are low in strength because of the resistance of the resins to solvents. However, procedures have been evolved for the curing of these adhesives, some at room temperature and some at elevated temperatures, and lap joints having a shear strength of 300 to 500 lb/in^2 can be made with most of the rubber- and polyester-based adhesives that are now available.

Diesel Deodorant

TESTS carried out by an independent laboratory appear to confirm that REDeX D.D. diesel deodorant, used to deodorize diesel fuel in bulk, improves the odour of diesel exhaust gases and reduces the lachrymal effects of nasal irritation by the gases. Both water and exhaust temperatures are said to have been lower when REDeX D.D. was used than when untreated fuel was employed in the tests. The carbon dioxide and oxygen contents of the exhaust gases remained about the same, but the carbon monoxide content was lowered. Not only was the soot and carbon number materially reduced but the group of aldehydes was also reduced from an average reading of 5 to one of 3. Further details can be obtained from Redex Ltd, 365 Chiswick High Road, London, W.4.

Power Supply Unit

A FULLY transistorized power supply unit, for operation at 30 V and 3 A, has been developed by Rotax Ltd. (Process Control Group), Chase Road, London, N.W.10. One of its features is a new filter circuit enabling the number of transistors used to be kept to a minimum. It is claimed that, by virtue of the employment of this circuit, and the consequent simplicity of the unit, the overall reliability is good. The stabilized voltage output is variable from zero to the maximum, and the overall stability factor is 1 : 1,200. A d.c. resistance of less than 0·01 ohm is quoted, and an adjustable device, for overload protection, is also provided.

Rust Preventive

RECENTLY a temporary rust preventive has been announced which need not be removed before a painting operation. It is called Dricote and is manufactured by Croda Ltd, Cowick Hall, Snaith, Goole, Yorkshire. The part to be treated is first degreased in the normal way, after which Dricote is applied by spraying, dipping or flowing.

Its drying time at room temperature is 30 to 40 min, and at 100 to 150 deg F is 2 to 3 min. During the initial drying stages, treated objects should not be allowed to come into direct contact with water. All of the commonly used finishing coats, except those based on acrylic or methacrylic resins, vinylidene chloride resins, or nitrocellulose, will adhere strongly to the treated surfaces.

Dricote is a composition of plastics materials, etching agents and solvents, and its two functions are to protect metals against rust or corrosion and to prevent the spread of existing corrosion. For delivery during the application process, it can be placed in mild steel containers, but lead-lined or enamel containers are, nevertheless, preferable. During storage, the liquid is stable, and is packed in stone jars, polythene bottles or rubber-lined drums. It is inflammable, and, because it contains acidic substances, can be dangerous in contact with the skin, if not rinsed off quickly.

The manufacturers say that dip application of Dricote gives the best results, but if the brushing method is employed it is best to apply two coats. For the indoor storage of steel, the coating gives protection for several months and still has a suitable surface for a finishing coat.

New Plant and Tools

Recent Interesting Developments in Production Equipment

AN addition has been made to the "Staffa" range of bending machines, manufactured by Chamberlain Industries Ltd, Staffa Works, Argall Avenue, London, E.10. By the fitting of extended centre and bending-arm spindles, these machines, which are designated "Staffa-Pedrick" benders, can form two identical, widely spaced bends, rapidly and simultaneously, in parallel bars, tubes and extruded sections. Removable spacing collars are incorporated on these spindles, their lengths being appropriate to the spacing of the parallel tubes, and the spindles are readily interchangeable to suit both these spacings and, of course, the outer diameters of the tubes.

In this range, the machines are in three sizes, and bends are formed by a rotary head, in conjunction with a stationary die and a swinging bending arm. The table of each machine is 30 in from the floor, and the driving motor is under it and enclosed by the circular base, which can be of either mild steel or cast iron. Control of the forming operations is effected by push buttons, and the incorporation of limit switches enables the machine, once it has been started, to bend to the desired curvature, reverse and then return to the starting position and stop, all without the need for manual attention.

These machines, as well as being able to form the bends described, can be adapted to bend several stacked tubes at the same time. In this range the smallest machine, the PA/3, has a 3 h.p. braked motor and can apply a bending moment of 25,000 lb-in, which is adequate for a 1 in diameter mild steel bar. A copper busbar of 2 in × ¼ in section can, on this machine, be bent edgewise to an inside radius of ¾ in.

By virtue of their extended spindles, the machines in this range are able to form two identical bends in widely spaced parallel bars
(Chamberlain Industries Ltd.)

When pressure is applied to the front leg of this instrument, the hardness of a light alloy or plastics material is indicated on the dial
(Industrial Instrument Services Co.)

The two larger models are designated PA/5 and PA/7, and each has a 5 h.p. braked motor, which applies a bending moment of 55,000 lb-in. One of these two machines, the PA/7, is the heavy duty version of the other, and is equipped with relay control for duplicate and semi-automatic bending operations. On the smaller one, a copper busbar of 3 in × ¼ in section can be bent to a minimum inside radius of 1 in, and on the larger one the figures are respectively 4 in × ¼ in and 1½ in.

Automatic billet heating furnace

Recently announced by Industrial Furnaces Ltd, Kingswinford, Staffordshire, is an automatic gas-fired billet heating furnace. It is in the form of a tall cylinder, and the billets are fed one by one at a constant rate into an aperture at the top. They slowly move round each of eight stacked platforms, dropping through a hole from one platform to the next at the end of each rotation. Thus, at each level, they absorb more heat, until they are ejected at the bottom of the furnace.

There is a central, vertical shaft, which has eight sets of radial arms to move the billets round their platforms. This shaft extends through the bottom of the furnace, where it is connected to the driving motor, which can be either pneumatically or electrically operated. The motor and driving gear are enclosed by a downward extension of the furnace's outer casing, which is of fabricated plate steel construction.

Inside the furnace, most of the working parts of the mechanism are nickel-chromium castings, but the vertical shaft is of stainless steel. Coal gas burners, with natural draught, supply the heat, and there is automatic control of temperature. The maximum working temperature is 900 deg C.

Although the billet feed drive is mechanical, manual control can be substituted if the desired rate of discharge

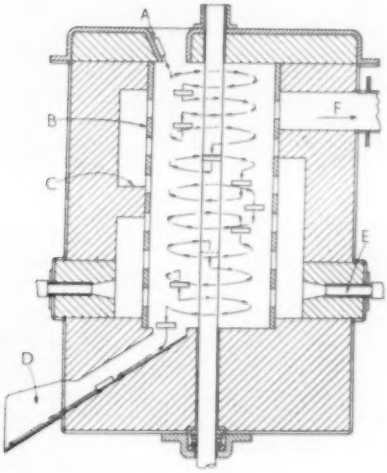
is low enough. Insulation limits the temperature of the outer casing. The construction of the furnace is claimed to be very robust, in order to withstand continuous use in areas adjacent to presses and drop hammers.

Hardness tester

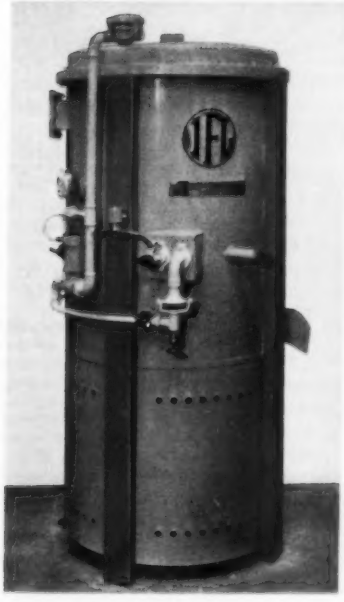
An instrument which should be of use to departments employing unskilled inspection personnel is being marketed in this country by Industrial Instrument Services Co, Elkington Street, Aston, Birmingham, 6. It is the Impressor portable hardness-testing instrument, made by the American Barber-Colman Co, and intended for use on light alloys, copper, and softer materials such as plastics. The hardness reading is indicated on a circular dial when the instrument is pressed against the material being tested.

The dial is divided into one hundred graduations, and the instrument records relative hardnesses rather than figures complying with any absolute scale. The readings can, however, be approximately related to standard scales, by the use of graphs supplied by the agents. Three models are available, the choice depending on the range of hardnesses required. Type GYZJ 934-1 is for soft metals and hard plastics, type GYZJ 935 is for soft plastics and very soft metals, and type GYZJ 936 is for materials such as leather and linoleum.

When being used on a horizontal surface, the instrument rests on three legs, one of which is the indenter. It is possible, however, to operate the tester in any position and in any space that will allow room for the operator's hand. The tester weighs 12 oz and is supplied complete with adjusting wrenches and spare indenters.

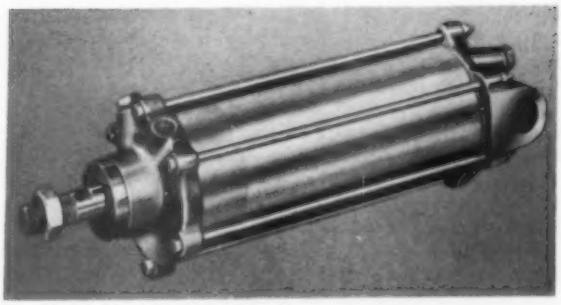


A *Billet feed*
B *Retort casing*
C *Gas flow baffle*
D *Delivery chute*
E *Gas burner*
F *Waste gas outlet*



Left: Furnace for automatic heating of small billets. These are fed in at the top, and travel in a helical path while being heated. Inside the lower half of the casing is the motor and driving gear. Above: Diagrammatic illustration of the furnace

(Industrial Furnaces Ltd.)



Heavy duty air cylinders with Duralumin barrels and end fittings. There are two ports at each end, so series coupling is simplified

(Benton and Stone Ltd.)

Heavy duty air cylinders

As an addition to their existing "Enots" range of standard duty air cylinders of 4½ and 6 in bore, Benton and Stone Ltd, of Aston Brook Street, Birmingham, 6, have recently announced a series of heavy duty, double acting cylinders of the same two basic dimensions. The barrels are made of Duralumin and the piston rods of stainless steel. Duralumin is also the material of the end attachment fittings, which are available in a variety of shapes, to suit different methods of mounting the cylinders. These fittings include foot, flange, trunnion and screw mountings; combinations of any two of these can, of course, be installed at opposite ends of the same cylinder.

Each end fitting contains two ports, taking ¼ in o.d. tube, so that dual lines can be attached if higher operating speeds than normal are called for. This design feature also simplifies the connecting in series of several units. According to requirements, the cylinders can be supplied either with or without internal cushioning. Uncushioned cylinders are available, from stock, with strokes of 1 in, 2 in, 3 in, 6 in, 9 in or 12 in, but the cushioned ones have a minimum stroke of 3 in. The manufacturers can supply to special order cylinders, outside the standard range, having strokes up to 7 feet.

Included in the specification of these cylinders are features such as piston rod bearings of oil-impregnated bronze, and scraper seals fitted to the piston rod housings to protect the standard seals. When operating with air at a pressure of 80 lb/in^2, uncushioned cylinders of 4½ in bore consume approximately 0·054 ft^3 of air per inch of stroke, and those of 6 in bore 0·105 ft^3; these figures are increased slightly for cushioned cylinders, as the presence of cushioning equipment in a cylinder has the effect of increasing its length.

Special purpose drilling equipment

In the range of equipment manufactured by W. J. Meddings Ltd, of Ipswich Road Trading Estate, Slough, Bucks, there are not only drilling and tapping units but also devices for controlling the rates of feeds of these tools. All this equipment, which is termed the Pacera special purpose machinery, is designed for assembly into automatic

or semi-automatic multi-station drilling machines, and yet a high degree of interchangeability is maintained to cater for the possibility of changes being introduced into the design of the drilled components.

The Pacera range is divided into three classifications: feed units, drilling machines and automatic drilling heads. Conventional drilling machines can, if desired, be adapted to semi-automatic operation by the addition of Pacera feed units, thus enabling one operator to supervise two or more machines simultaneously.

The Pacera Maxam air hydraulic feed unit is intended primarily for the conversion of drilling machines from manual to power feed. It is also suitable for the power feeding on milling and grinding machines. This unit, which weighs 30 lb, occupies a space approximately 5¼ in × 7½ in × 21½ in, and in general is in the form of two parallel cylinders, with interconnecting pipework. One of the cylinders encloses a toothed rack whose movements are powered pneumatically but controlled hydraulically by a system, in the other cylinder, in which there are vents and valves governing the flow of oil. The manual controls for this circuit are mounted externally, so that a complete feed cycle can be set up very quickly. A typical cycle is: fast approach to workpiece; infinitely variable feed rate; slow breakthrough of drill towards end of cycle; fast return to start position.

The toothed rack drives a pinion which is mounted half way along the enclosing cylinder, and a shaft connects it with the rack and pinion feed mechanism on the drilling machine. With an air supply at a pressure of 80 lb/in^2, the output torque obtained is 165 lb-in. The swept volume of air for a complete cycle is 0·027 ft^3.

In the Pacera range of vertical drilling machines there are five models, each equipped with a Maxam feed unit. They are available as either floor-mounted or bench-mounted units, and with a choice of three control systems: automatic reciprocation; pedal-controlled feed with automatic return; and hand-controlled feed with automatic return. All five machines can be used with drills of up to ½ in diameter. They are available in various heights, and with a choice of column diameter, reach and spindle speeds.

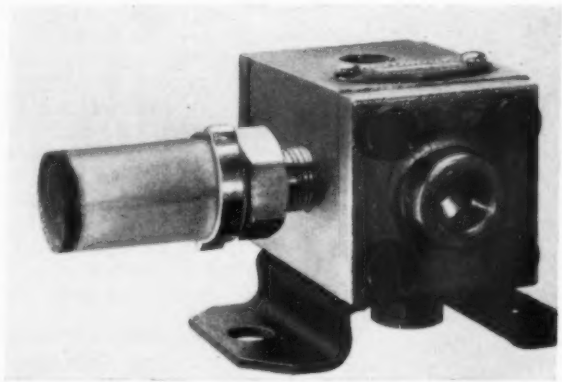
Automatic drilling heads, the third group of machines in the Pacera range, are self-contained assemblies, in each of which a Maxam feed unit is coupled to an electrically driven head. These units have various types of gear drives: one, for instance, embodies a Kopp variator, and another has five sets of interchangeable gears and three interchangeable motors. All of the standard models of head can be used for drilling holes of a maximum of ½ in diameter in mild steel, but 1 in diameter holes can be drilled if a Booster Unit is employed in conjunction with the machine.

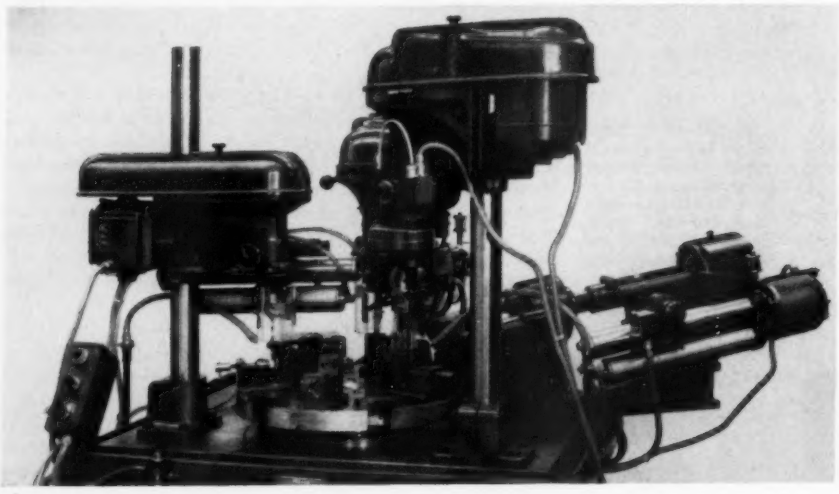
Fluid blending machine

This machine is intended for the accurate blending of two fluids, such as water and anti-freeze liquid, at any concentration from 5 per cent to 40 per cent. It is small enough to be built into a portable or wall-mounted unit, and is operated by mains water supply pressure. The illustration shows a completely self-contained unit mounted on casters: within the body of the machine is the tank for storing the secondary liquid, and at the right, above the coiled delivery hose, is the inlet connection for the water supply.

Two double-acting hydraulic cylinders lie with their axes parallel and horizontal, at the top of the machine. Water passes through a change-over valve into the first of these, flowing into one end of the cylinder until its piston reaches full travel, during which time the water already on the other side of the piston is flowing out into a delivery pipe. At the end of the stroke, the opposite ends of the cylinder reverse their functions so the flow of water is intermittent.

The piston rods of the two cylinders are connected to a long horizontal lever pivoted at a point which, as viewed in the illustration, is beyond the axis of the second cylinder, so that this cylinder has a stroke less than that of the first. Since the secondary liquid is pumped from the second cylinder into the delivery pipe, it follows that the concentration of resultant mixture is determined by the ratio of the





Above: Silencer for exhausts of pneumatically operated tools. The exhausted air passes through the body to the left, which is of porous plastics material
(Martonair Ltd.)

Left: Typical special-purpose machine. A component of the steering mechanism of a car receives six drilling and tapping operations, on a six-station rotary table. All of the machines are standard items, and rapid change-over is possible if the design of the part is altered
(W. J. Meddings Ltd.)

Above: Horizontal bandsaw for cutting bars and tubes. There is hydraulic control of feed, and an automatic counter unit is also incorporated
(Monks and Crane Ltd.)

Left: Two fluids, such as water and anti-freeze, can be accurately blended in this machine, which is operated by mains water pressure
(Suba Hydraulics Ltd.)

strokes of the two piston rods. Provision is made for adjustment of the position of the second cylinder relative to the first, so that this ratio can be altered to give the required concentration.

Before passing into the delivery hose, the mixture flows through a chamber containing baffles which ensure that thorough intermingling takes place. Prior to the start of any mixing operation, this machine has to be primed by actuation of a lever on the side. The machine is manufactured by Suba Hydraulics Ltd, Limes Place, Limes Road, West Croydon, Surrey, who also produce similar equipment for blending a number of liquids to suit individual requirements.

Silencer for air exhausts

In many workshops where pneumatically operated tools are in continuous operation, the high noise level of the exhausts is one of the most disturbing features. It is now widely accepted that efforts to ensure quieter working conditions can be rewarded by reduced fatigue among the machine operators, and, in all probability, by increased production. A silencer for the exhausts of machines with large cylinders or high-speed rotary components is now being marketed by Martonair Ltd, Parkshot, Richmond, Surrey, and the claim is made that this device has the effect of reducing the exhaust noise of a machine to a level lower than that of the mechanical noise.

It was the aim of the manufacturers to produce a compact unit to silence effectively the effluent air without seriously impairing the efficiency of the machine to which it is fixed. In this silencer, the air is passed through a layer of porous plastics material, and the back-pressure so caused is stated to reduce the speeds of silenced machines by only 15 per cent. This porous component is of cup shape, and is mounted on a brass union, one end of which is threaded for screwing into the exhaust orifice of the machine.

The range of silencers available comprises six models, the smallest having a $\frac{1}{4}$ in B.S.P. mounting thread, and the largest 1 in B.S.P. Some typical figures quoted for noise reductions are as follows: for a machine working with a line pressure of 80 lb/in^2, 92 decibels before fitting a $\frac{1}{4}$ in silencer, and 66 decibels after; for a larger machine with the same line pressure, 120 decibels before fitting a 1 in silencer, and 95 decibels after. In this range, the dimensions of the type N.4001 unit, which is the smallest, are: protruding length $1\frac{5}{16}$ in, overall diameter $\frac{21}{32}$ in; those of the type N.4008, the largest, are respectively $12\frac{1}{2}$ in and $2\frac{11}{16}$ in.

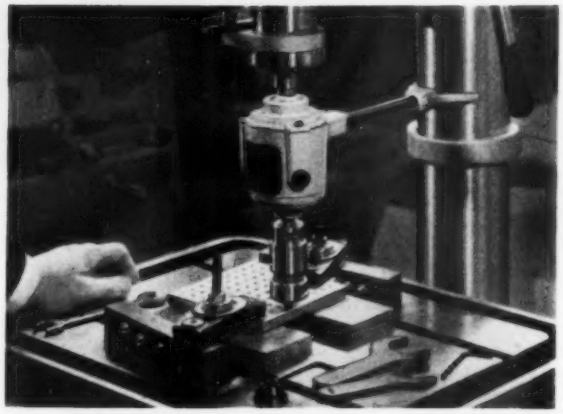
Horizontal bandsaw

An automatic, hydraulically operated, horizontal bandsaw, for rapidly cutting long bars and tubes, is being marketed by Monks and Crane Ltd, of Garretts Green Lane, Birmingham 33. It is called the Fortemat BA 241, and can accommodate bars up to 10 in diameter or 10 in square. The claim is made that, by comparison with a conventional reciprocating machine, this machine gives a higher degree of precision and finish to the ends of the cut bars and, by virtue of its thinner saw blade, is considerably less wasteful of stock material. There is also, of course, a much higher production rate possible with this saw than is the case with a reciprocating saw, since the cutting action is continuous.

As is the case with the reciprocating saw, the blade is housed in a swivelling arm which, for each cut, descends under the influence of its own weight. At the swivelling end of this arm is the housing that contains the motor and driving pulley for the saw band, and at the other end, joined to it by a stout tube, is the housing for the idler pulley. Within the tube is a weight whose axial position is adjustable so that the effective dead weight bearing on the blade can be varied to suit requirements.

Since it is obviously out of the question to have a bandsaw's line of motion co-planar with the axis of a long workpiece, the pulleys are offset towards the rear of the machine, and there are guide rollers in the cutting area to deflect the blade into the appropriate attitude relative to the workpiece. Two hydraulically operated vices are incorporated in the machine, the first to hold work during a cut, the second to feed the bar forward between cuts, while the grip of the first is relaxed. This feeding motion is also

Above: These storage containers can be stacked either one on top of the other, or in standardized racks. Each container has two carrying bars, which are designed to serve several purposes, as shown
(Bradley and Co. Ltd.)



Right: Within this tapping attachment is a clutch unit which, when pressure is relaxed, reverses the direction of rotation of the tap
(Monks and Crane Ltd.)

hydraulically actuated, and the length of the parts is determined by a screwed stop, adjacent to which is a graduated scale to facilitate setting.

Prior to a series of cuts, the sawing arm, which is raised hydraulically, is allowed to fall to a pre-set level just above the workpiece, and the operation begins. When the bar has been sawn through, the arm contacts a limit switch and is raised clear of the work while the stock is fed forward, and then the cycle is repeated. Among the controls is a counting device that switches the machine off when the set number of parts has been cut.

The saw band on this machine is 12 ft long × 1 in × 0·034 in and it has a cone drive system by virtue of which stepless variations of cutting speed, within the range 70 to 225 ft/min, are possible. This top limit can, to special order, be raised to 450 ft/min.

Storage containers

Recently announced by Bradley & Co. Ltd, of Albion Works, Bilston, Staffs, is the Spacesaver range of storage and material handling containers and racks. The containers are open-topped steel boxes, heavily swaged for strength, and designed to afford easy access to the contents when the boxes are stacked either on top of each other or in racks. So that it is easy to see and reach into the containers, one end of each is only half the depth of the other and is canted outwards.

The upper edges of each container are lipped, so that another stacked above it is restrained from lateral movement. All are 8 in high, and are available in the following combinations of sizes: lengths of 13 in, 19 in and 25 in; and widths of 9 in, 12 in and 18 in. To complement this range, there are standard shelf units which hold three layers of containers, and which can be built into rack assemblies to make the best use of available storage space.

Accessories are available for these storage units, to increase the number of uses to which they can be put and to facilitate the normal storage and handling operations. Among these are top covers and front flaps which hook into the two high transverse bars incorporated in each container, one at the front and one towards the rear; these bars, incidentally, are also for use as lifting handles. There is also a chute which hooks into the front bar and allows small parts to be poured straight in, and there are small slotted plates which stand against the two ends of a container to locate longitudinal partitions for dividing the containers into two, three or four sections.

The containers are available with either a hot dipped, galvanized finish or a stove enamelled finish in any of a variety of colours, and the shelf units with either a galvanized or a metallic grey enamel finish. If it is desired, the suppliers will design an installation to suit a customer's requirements.

Tapping attachment

By the addition of an attachment known as the Versatapper unit, a drilling machine can be adapted to perform tapping operations. The unit is a small cylindrical gearbox with, at one end, an input shaft for coupling to the drill spindle, and, coaxially at the other, a tap holder. From the side of the unit protrudes a forked arm, of adjustable length, which loosely straddles the pillar of the drilling machine and thus prevents rotation of the gearbox, without interfering with its vertical movement. Within the gearbox is an epicyclic train which reduces the speed of the tap holder to a quarter of that of the input shaft and transmits drive, in the normal direction, as long as there is a downward pressure on the drill spindle. During a tapping operation, therefore, the operator maintains a slight pressure on the feed lever of the drilling machine, and allows the tap to feed into the hole at its own speed.

When the operator attempts to raise the spindle, a friction clutch is engaged which reverses the rotation, so that the tap can be withdrawn from its hole. Thus, the tap can be halted or withdrawn merely by the pressure on the feed lever of the machine. It will be appreciated that, once the length of the forked arm has been set to suit a given drilling machine, the Versatapper can be fitted or removed in no more time than is required for fitting a twist drill. The unit can transmit torque sufficient to tap holes of up to $\frac{1}{2}$ in diameter in mild steel, and up to $\frac{3}{4}$ in diameter in softer materials.

Two models are available; the first is model 6100, intended for general workshop use and fitted with a straight shank input shaft; the second is model 6200, which has a No. 2 Morse taper arbor and is more suitable for semi-permanent installation and where a higher degree of accuracy is desired. The model 6200 is slightly the larger of the two, at $10\frac{3}{4}$ in overall length, and it weighs $5\frac{1}{2}$ lb. In this country, the Versatapper is distributed by Monks and Crane Ltd, of Garretts Green Lane, Birmingham 33.

SPECIAL PURPOSE TRUCK

A Vehicle in Which Mechanical Handling Equipment for Discharging the Load is Incorporated

VEHICLES specially designed for the bulk transport of goods are being increasingly widely used. Generally, an essential feature is mechanical handling equipment for the discharge of the load. Among the latest to be introduced is the Pneumarotor, which is one of the already wide range of specialist vehicles offered by Bonallack and Sons Ltd, of Nevendon Works, Basildon, Essex.

A noteworthy feature of this vehicle is its ability to carry grains and feeding stuffs as either a single bulk load or three entirely separate ones, and to discharge them either pneumatically or by end-tipping. Two versions of the vehicle are available, both in several sizes: they differ only in that the body is in one case equipped with fixed sides and in the other with easily removable drop-sides and tail-gate, so that the vehicle can be converted into a flat platform truck. Both versions can be supplied, according to the customer's requirements, with either a canvas cover sheet or a removable aluminium alloy roof, and any one of a variety of tipping chassis can be used as the basis of the vehicle.

The body is constructed of light aluminium alloy sheet and extruded sections, and the load carrying compartment is floored with the Bonallack patent interlocking extruded alloy decking. A mild steel sub-frame carries the assembly, so the fitting of tipping gear has presented no difficult problems. Two removable partitions, hinged at the top, separate the interior into three compartments of equal capacity, in order that three completely different loads can be carried simultaneously. These partitions are locked in the vertical position by bolts operated from the outside and, when released, swing to the angle of tip, so that the load can slide freely to the rear of the vehicle.

One of the most interesting features is the pneumatic discharge equipment, compressed air for which is supplied by a belt-driven Wellworthy compressor. Among the advantages of this compressor is its silent running. Immediately below the floor at the tail end of the vehicle is a full width, sunken hopper, fitted with sliding traps for the control of the input of the load, through slots, to the rotary delivery valve immediately below. This valve also extends the full width of the body, and it is driven hydraulically by the pump used for operating the tipping gear. A dog clutch is incorporated so that the tipping gear can be employed independently if the pneumatic discharge equipment is not required to be used.

The delivery valve comprises a rotor having a number of radial vanes, and it operates in a cylindrical housing. Slots along the top of the housing form the inlet ports, through which, as previously mentioned, the load drops from the hopper into the spaces between the radial vanes. The continuous rotation of the valve carries the material from the uppermost to the lowermost position in the cylindrical housing, where the spaces between the rotors come, in turn, into line with the compressed air inlet port at one end: the air drives the contents along the full length of the rotor and out through the delivery port which is situated at the opposite end.

When this pneumatic discharge equipment is employed, tipping is necessary only in the final stages, in order to shift the residue of the load from the forward end of the compartment to the hopper at the rear. At the conclusion of the operation, the compartment is completely empty, so there is no need for the operator to enter it at all. This, and the quietness of operation of the equipment, are both important in certain applications, for example where delivery is to be made to farms.

The rates of discharge are dependent on the type of material being handled and the height or distance to which they are being delivered. For discharge at heights of 20 to 40 ft, the following rates are recommended: grain, 19 ton/hr; meal, 15 ton/hr; crumbles, 12 ton/hr; pellets, 7 ton/hr; cubes, 7 ton/hr. Faster rates, may, however, be practicable.

Rear end of the Bonallack Pneumarotor truck, showing the rotary delivery valve. The four handles just below the level of the floor of the vehicle are on pull-out shutters by means of which the flow of the load from the hoppers to the rotary valve is regulated manually

Improved Dry Lubrication

DRY-FILM bonded coatings of molybdenum disulphide have been found of considerable value during running-in and in cases where the operating conditions are unusually severe. Such coatings are particularly useful where contamination of the product by conventional lubricants must be avoided. An established coating of this type is Moly-Paul Moly-VI-Bond, which has been awarded DTD Approval Number 900/4648. It can be applied to metallic or non-metallic surfaces by brushing or dipping.

As a result of recent development work, Moly-VI-Bond now has a higher resistance than before to abrasion, oxidation and attack by acids and alkalis. These improvements have been effected by the addition of about 2 per cent of a special composite resin, which has the secondary advantage of increasing the elasticity of the coating, thus facilitating any processing of the product after application. The additive is colourless, non-toxic and free from taste or smell. Hot curing of the new coating is necessary, however, whereas the earlier Moly-VI-Bond would cure at room temperature. Sample packages of the improved material are available for experimental purposes, price 7s 6d, from K. S. Paul (Molybdenum Disulphide) Ltd., Angel Road, London, N.18.

LARRAD HYDRAJAWS

Multi-point, Hydraulically-compensated, Closed-circuit, Clamping Units for use in Machine Vices. Variants Include Hydraulically-operated Clamps and Some Work-holding Fixtures

METHODS of holding workpieces on the tables of machine tools have remained substantially unchanged over the years and in some respects, since they do not match the advances made in machine tools and cutting tools, may impose limitations on potential production capacity. This largely arises owing to the fundamental inflexibility of the conventional, parallel-jawed, machine vice, combined with the fact that normal manufacturing tolerances do not ensure that components, particularly castings and forgings, are of an exactly uniform size.

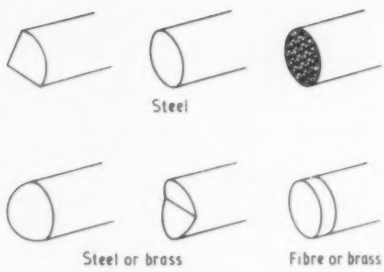
Such expedients as pivoting, tilting, or angled vice jaws are of value in certain instances but offer only a partial solution to the problems raised in securing irregularly shaped workpieces or in the simultaneous holding of several small components. Invariably some adaptation can be made to meet the requirements posed by individual components. Frequently, however, the methods employed are time-consuming in operation and usually there is no assurance that clamping pressure is uniformly applied.

Larrad Hydrajaw unit, with coned plungers, for use in standard type machine vices

Many of the shortcomings of conventional vices and clamps can be eliminated by the use of hydraulic vice jaws and clamping fixtures termed Hydrajaws. These patented devices, manufactured by Larrad (Hydrajaws) Ltd. and distributed in England and Wales by Alfred Herbert Ltd, Edgwick Works, Coventry, are of simple construction and exploit the principle of the uniform distribution of applied pressure throughout a liquid. Produced in a range of sizes, the basic unit for insertion in a machine vice consists of a mild steel rectangular block provided with a series of plungers protruding from one face to engage the workpiece. Behind the plungers, the bores are filled with hydraulic oil and are interconnected by drilled conduits. By this means the plungers are enabled to adjust their individual positions automatically while the vice is being closed and to exert equal pressure when the vice is fully tightened.

Rango of Sizes and Types

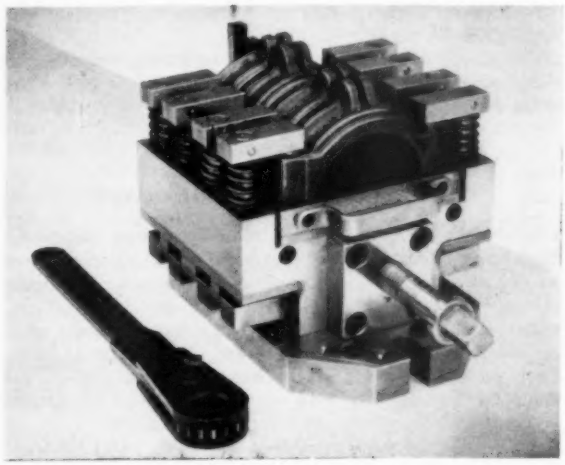
A range of eight standard Hydrajaws is available, each with a choice of six designs of plunger heads. The smaller sizes of these units can be supplied with matching multiple-vee blocks, suitable for holding a number of small components, or with blocks having a single horizontal vee-section. Operating on the same principle as the standard units is a further range of six Hydrajaw clamps, resembling in appearance conventional, solid, jig-and-fixture clamps. The advantage of the Hydrajaw clamp is that in place of the normal, solid, clamping pads there is a row of plungers in interconnected bores filled with hydraulic oil to provide fully compensated clamping. The use of spherical seatings and washers is completely unnecessary with a Hydrajaw clamp.



Various types of plunger heads are available for all standard Hydrajaws

A logical development of the standard vice jaws and clamps is the design of a series of Hydrajaw fixtures. In these the pressure is applied to the fluid by means of a screwed master plunger which can be operated by a ratchet wrench. In other respects the principle remains the same; of a hydraulically compensated, multi-point, clamping unit. The advantages are that irregularly shaped components or a number of small components can be held by one Hydrajaw clamp actuated by turning a single screw. Conventional methods of holding these components with a series of small clamps each having a separate clamping screw can be discarded and considerable reductions effected in floor-to-

In this milling fixture the plungers actuate pairs of clamps to hold four bearing caps. Parts are located on magazines for rapid loading



floor times. Fixtures are available in a standard range, and there is also a planer unit having three, angled, spiking-down plungers designed specifically for use on planing machines, heavy-duty milling machines, and large shaping machines.

Special-purpose fixtures

In cases where the range of standard equipment does not meet the requirements posed by a specific production problem, the manufacturers will advise on the problem, suggest improved methods, or design special-purpose Hydrajaw fixtures. In general, economies in floor-to-floor times and improvements in the quality of work may be expected from the use of Hydrajaw units. Such advantages are obtained not only by reason of the facility with which several clamping plungers can be operated by a single action but also due to the extremely high pressures that can be applied. This characteristic of the Hydrajaw principle enables several components to be machined simultaneously by a single cutting tool while set up with the cutting pressure exerted along, instead of transverse to, the jaw opening of the vice, and without recourse to end stops. Hitherto, with need to machine across the jaws, or towards the fixed jaw, the number of components that could be machined at the same time was frequently dependent upon the number of cutters that could be ganged on the machine spindle.

An illustration on the Contents page, showing a heavy cut being taken by a shaper on a workpiece in line with the vice jaw opening, and at considerable height above the jaws, is indicative of how securely work can be held with a single Hydrajaw unit. The potentialities of the device have not yet been fully explored and new instances are continually being reported of successful solutions of clamping problems.

ALUMINIUM HOLDING FURNACES

Wild-Barfield Induction-Heated, Mains-Frequency Units Specially Developed for Use in the Alumasc Low-Pressure Diecasting Process

ALUMINIUM diecasting by the Alumasc low-pressure process offers several advantages over the more conventional gravity diecasting method. Reference to the diagrammatic section of a furnace will serve to make clear a brief description of the process. The molten metal is held at a controlled casting temperature in the crucible. Air at a specific pressure is introduced above the surface of the metal, which is forced up through a central feed tube, termed the stalk, and into the die mounted directly on the furnace casing cover.

The die is vented to atmosphere so that no air can be entrapped, and only clean metal is used since that withdrawn from the crucible is taken from neither the top nor the bottom where dross or impurities collect. As the pressure applied is higher than is practical when using the gravity method, a denser casting is produced and there is a constant feed of fresh metal to compensate for shrinkage as the casting "freezes". The need for a substantial header to feed metal to the cast disappears. Less metal has to be melted for each casting and there is very little re-melting and, thus, a considerable reduction in melting costs is effected. When pressure is relieved, on solidification of the casting, metal in the stalk falls by gravity in the molten mass in the crucible. A supplementary heater at the throat ensures that no interruption of production can occur due to inadvertent freezing of metal in the stalk. Excess metal on any casting is extremely low and normally will not be more than a few ounces, even on large castings. It follows that substantial reductions can be made in the usual costs for cut-off and fettling.

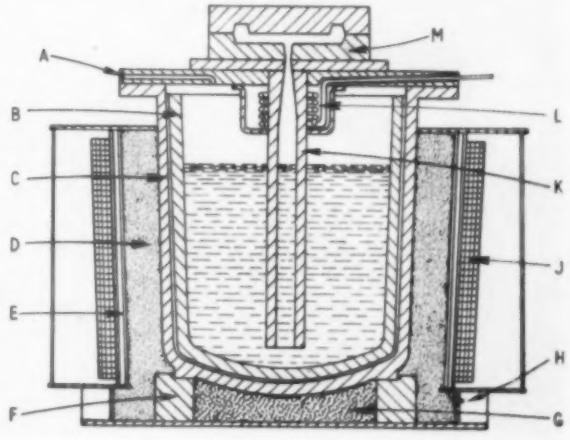
In collaboration with Alumasc Ltd, Wild-Barfield Electric Furnaces Ltd, of Otterspool Way, Watford By-Pass, Watford, Herts, built in 1957 a new type of aluminium holding furnace specially adapted for the Alumasc process. The original equipment had a capacity of some 300 lb of molten aluminium and a melting rate of 60-80 lb/hr. Currently, a range of three standard furnaces is produced and brief details of their specifications are given in the appended table.

Constructionally, the furnace has a fabricated mild steel case, supported where necessary by steel angle sections. This case encloses a split, stainless steel liner which acts as a former for the windings. The top ring of the case is designed to position the melting pot, or crucible, which is provided with a flange to locate in a sand seal to protect effectively the furnace insulation. At its base, the case is closed by a heat-resisting plate fitted with a cast base ring to support the crucible.

For insulation, the annular space between the crucible and the winding former is filled with magnesium oxide lagging powder, introduced on installation. The furnace winding itself is of heavily insulated aluminium strip, which is carried by, yet insulated from, the split, stainless steel liner. Silicone-bonded mica and glass, further impregnated with silicone varnish is used to insulate the winding. In order that the winding may operate at as low a temperature as possible, it is situated in the annular space afforded by a double skin and subjected to the cooling effect of air blown

Diagrammatic section of Wild-Barfield mains-frequency, induction-heated aluminium holding furnace for Alumasc low-pressure die-casting process

A *pressure-air inlet;* **B** *plumbago liner;* **C** *cast iron crucible;* **D** *magnesium-oxide insulation;* **E** *stainless steel liner;* **F** *support ring;* **G** *sand bed;* **H** *winding cooling-air inlet;* **J** *winding;* **K** *stalk;* **L** *throat heater;* **M** *die*



through that space. Nevertheless, as an additional precaution, to switch off the equipment in the event of the winding attaining an excessive temperature, an indicating millivoltmeter-type automatic controller is employed. The thermocouple of this instrument is attached to the inner winding former and a "broken thermocouple" safety device is incorporated and 20 ft of compensating leads are provided. Should molten metal escape through a crack in the cast iron crucible pot, an earth-leakage relay switches off the equipment and operates a warning light.

The crucible unit, which is the subject of a patent, consists of a cast iron pot which sits in a sand bed and carries a plumbago liner freely situated with an annular space of approximately 1 in between the outside of the plumbago liner and the inside of the cast iron pot. This arrangement allows the metal crucible to function as a pressure seal for the casting process, and the graphite liner to contain the molten metal, keeping it free from contamination during long casting runs. Once the cast iron pot has reached the "curie" point, no practical loss of current is experienced. Similar remarks apply to the graphite liner, so the overall current consumption is practically the same as for a single crucible.

STANDARD RANGE OF FURNACES

Model		30	75	100
RATING	At full power	25 kW	40 kW	60 kW
OPERATING TEMP.	Maximum	750 deg C	750 deg C	750 deg C
CAST IRON CRUCIBLE	Internal dia.	19 in	24 in	27 in
	Internal depth	30 in	30 in	37½ in
	Wall thickness	1 in	1¼ in	1¼ in
	Depth metal	24 in	24 in	32 in
PLUMBAGO LINER	Wall thickness	1 in	1 in	1½ in
CAPACITY	Nominal	260 lb	650 lb	1,000 lb

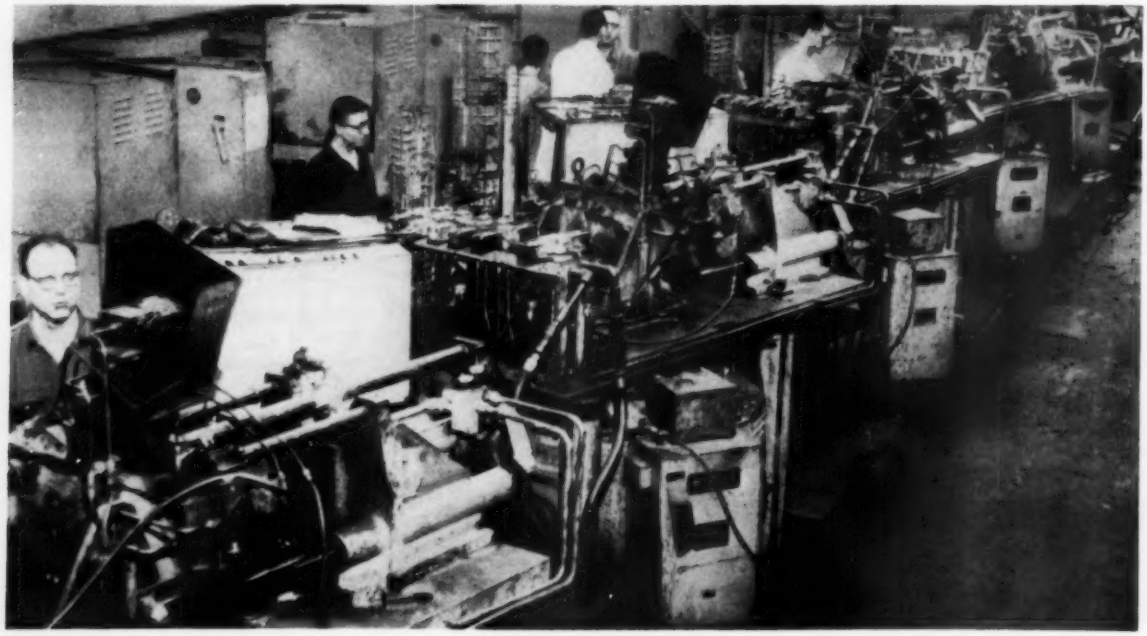
Supply is controlled from an ironclad, pillar-type contactor panel having a hinged front which is interlocked to prevent opening unless the isolator is in the "off" position. The panel houses a hand-operated isolator interlocked with the main contactor so that circuit is made and broken by the contactor; a main contactor with rolling butt contacts; and solenoid overloads with oil dashpots in the main furnace circuit. A bank of capacitors is included to correct the final power factor of the equipment to 0·9 and a transformer is provided to spread the single-phase load presented by the furnace winding over the three phases. Standard supply is 440 V, 3-phase, 50-cycle, 3 or 4 wire.

Advantages offered by the low-pressure aluminium diecasting process, when compared with the more conventional gravity diecasting method, has led to the process being carefully investigated by the automobile industry; in particular to the production of denser castings suitable for main engine components. A brief description of low-pressure diecast crankcases, cylinder heads, bell housings, and transmission casings for the Chevrolet Corvair engines was given in an earlier issue*.

One of the points in favour of the mains-frequency equipment arises from the fact that to obtain the best castings, the temperature of the melt should be controlled at a figure as little above melting point as possible—depending upon the components being cast—in order to avoid undue oxidation of the molten material. With Wild-Barfield holding furnaces, the necessary control is available and response to the temperature controller is virtually instantaneous. Initially, the Chevrolet Division of General Motor Corporation, U.S.A, placed an order for a number of furnaces with Wild-Barfield and subsequently ordered more. The total installed is now more than thirty. These units each have a capacity of some 700 lb molten aluminium. They are employed in making castings for the "Corvair" and an illustration shows part of the installation at the Chevrolet plant at Messina. It will be noted that opening and closing operations on the dies have been mechanized.

* "*Automobile Engineer*", *November*, 1959.

Part of the installation of Wild-Barfield, mains frequency, aluminium holding furnaces at the Messina U.S.A. plant of the Chevrolet Division of General Motors Corporation. Components for the Corvair air-cooled engine are produced, including crankcases, cylinder heads, and bell housings



Hartex
Centreless Grinding Machines

New Models Have a Wheel Balancer and a Compensator for Wheel-Dressing Angles

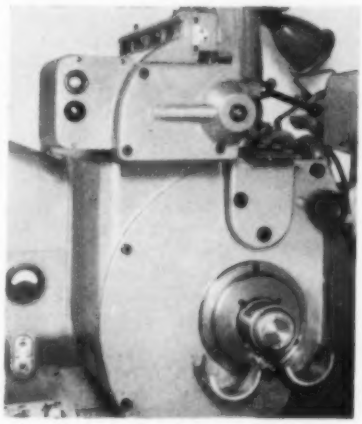
TWO new centreless grinding machines, Model BED. 4 for workpieces from 0·04 in to 2·0 in diameter, and Model BED. 5 handling work from 0·156 in to 4·75 in diameter, have recently been introduced by Hartex GmbH, of Berlin-Marienfelde, West Germany.

Their respective capacities when plunge grinding are up to 6·25 in and up to 10·0 in. Each model is built in two versions: Model BED. 4 is available for through-grinding only or for through-grinding and both manually operated and automatically controlled hydraulic plunge-grinding. The larger model, Model BED. 5, is produced in similar versions, but the simple machine for through-grinding incorporates additionally a manually operated plunge feed. An oscillating grinding wheel head can be fitted to the BED. 4 through-grinding only version, if required. Oscillation can be started or stopped while the machine is running.

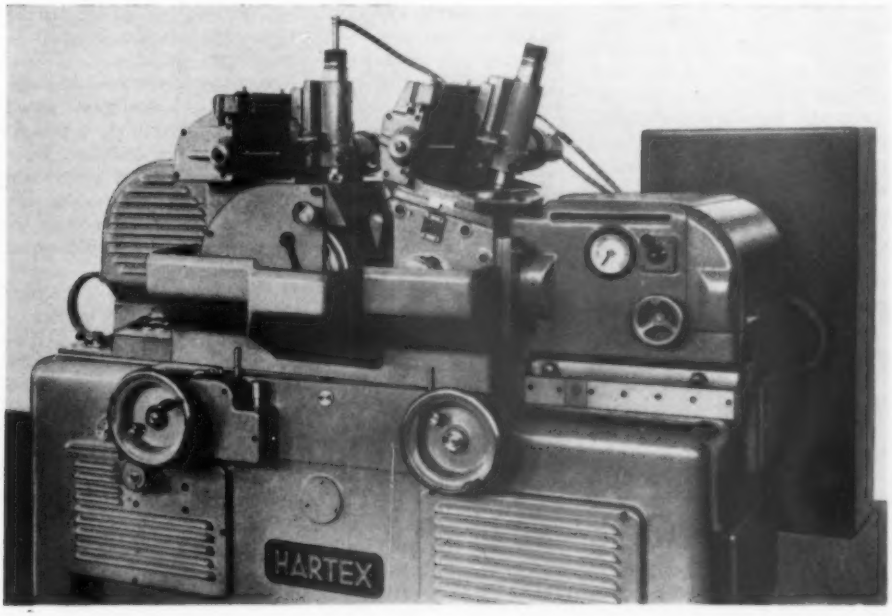
Referring specifically to Model BED. 5, both parallel and profiled components can be ground. Automatic magazine feeds and measuring and control equipment can be fitted. Bar grinding can be arranged, if desired, with bar guides up to 18 ft long at the front and rear of the machine. An important design principle, well established on earlier Hartex machines, is that both the grinding wheel and the control wheel carriages can be independently adjusted and traversed relative to the work axis. This obviates the need to provide horizontal adjustment of the workrest, which is rigidly supported on a bridge member mounted on the machine bed.

This feature confers a number of operational advantages. When setting the machine, the work can be placed in the desired position on the workrest and the wheel fed in immediately. If magazine loading is fitted there is no need to continually reset the magazine when wheel wear occurs since the workrest remains stationary. Similarly, it is not necessary to reset guides when bar grinding. Ejection of finished workpieces, especially shouldered components, is greatly facilitated by the automatic retraction of the control wheel. Workpieces fall between the workrest and the control wheel into a bin or on to a belt conveyor.

A vee-type workrest can be supplied for heavy workpieces. There, again, unloading of finished work is unimpeded. The control wheel retracts, leaving the work seated in the rest ready for axial ejection. So rigid is the support afforded to the workrest by the bridge member that, if required, vertical



Grinding wheel balancing device. Control rings are at the wheel axis and the "magic eye" indicator at the upper left of the wheel head

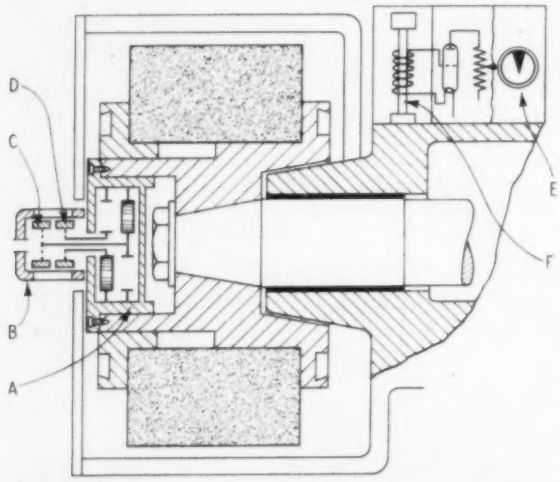


Hartex Model BED.5 centreless grinding machine for through- or plunge-grinding

adjustment of the rest height by a screw and nut device operated by a handwheel can be provided. This is of particular value when a machine is employed in the production of small batches of parts as it greatly reduces setting times. Where auxiliary equipment — magazine loaders, bar guides, or ejectors—are fitted, these require no adjustment when the rest height is altered as the work axis remains at a constant height.

On a machine arranged for through-grinding and manual plunge-grinding, version I, both the grinding wheel and the control wheel are adjusted manually. Plunge traverse of the grinding wheel is up to 0·028 in or up to 0·055 in and a trip mechanism permits precision adjustment in increments of 0·001 mm (0·00004 in). On version II, grinding and control wheel heads are traversed hydraulically when plunge grinding. Rapid approach, plunge feed, and rapid return of the grinding wheel can be controlled by push buttons or by an automatic cycle consisting of rapid approach, plunge feed, spark-out, rapid retract, and dwell. Spark-out and dwell periods are controlled by adjustable time relays having a range of from zero to 10 seconds.

Plunge feed rate can be separately varied for roughing and finishing; the changeover from roughing to finishing takes place automatically. The traverse of the plunge in-feed is steplessly variable by means of a handwheel and a pointer scale to a maximum of 0·040 in. Adjustments can be made in fine movements of 0·00004 in. Thus, the operator can set the plunge rate by means of a regulating valve whilst observing the speed of the pointer on the scale. Rapid traverse is also steplessly variable as regards total traverse and rate, giving rapid retraction to facilitate

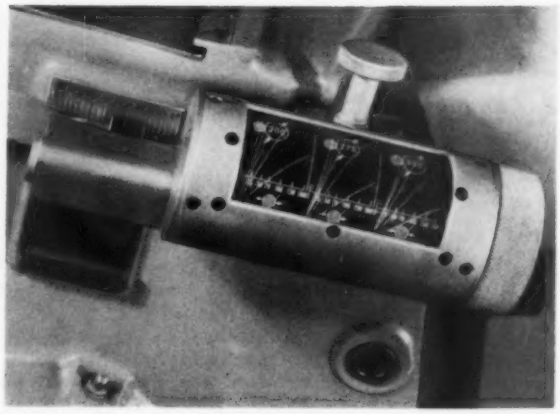


A *balancing unit;* **B** *control unit;* **C** *and* **D** *counterweights;* **E** *indicator unit,* **F** *vibrator*
Diagram of mechanical balancing unit and electronic "magic eye" indicator

loading and rapid approach to the work after the dwell.

Similar arrangements are provided for the control wheel and a selector switch allows the choice of two methods of movement in conjunction with the automatic cycle of operations. In the first, the control wheel retracts and immediately returns. This movement is used for workpieces that need to be ejected axially, and particularly for those having larger diameters intermediate the ends. The second method, in which the wheel dwells in the retracted position, is used for heavy workpieces carried on vee workrests and for shouldered work.

A 20 h.p. motor drives the grinding wheel which, in its maximum size, is 20 in diameter and 10 in wide and runs



Correction device for control wheel dressing attachment setting angles

at 1,200 r.p.m. Grinding spindle bearings are pressure lubricated and the machine is stopped automatically should the oil pressure fall below a pre-set value. A signal lamp indicates the correct functioning of the lubricating system.

No grinding wheel is a truly homogeneous body and its condition of balance is likely to undergo change as a consequence of wear and dressing, thereby affecting grinding accuracy. Hitherto, the wheel was balanced initially and it was necessary to remove the wheel for re-balancing. Since this entailed considerable down time and interrupted production it was frequently neglected. On this Hartex machine, a special built-in balancing device is available which facilitates balancing of the wheel on the machine spindle during operations without holding up production. The condition of balance can be checked immediately at any time during the working life of the wheel.

This device consists of a mechanical balancing unit and an electronic measuring and indicating unit, as shown in the diagram. The balancing unit rotates with the grinding wheel flange, which is furnished with the usual adjustable counterweights for coarse balancing. Projecting through the wheel guard, the operating control can be held stationary while the wheel is rotating. By means of two large milled rings, balancing weights within the rotating device can be moved so that their counter force can be made equal in direction and value to the prevailing unbalance.

Vibrations in the machine body are measured and indicated by the electronic unit. A mechanical vibrator tuned to the spindle speed vibrates in synchronization, is probed inductively, and changes in amplitude are indicated by a "magic eye". By adjusting the two setting rings and bringing the magic eye "fan" to its maximum value the wheel is re-balanced. The device admits correction of unbalance up to 1,300 cm-gr with a vibration amplitude of the machine from 0·5 to 0·1μ.

The trend in centreless grinding is for wheels to become wider and through-grinding rates to be raised by increasing the swivel angle of the control wheel. Under such condition, if the usual method of setting the dresser to the same angle as the control wheel is followed, the control wheel contour becomes too hollow and short workpieces may cease to be transported. An experienced operator could make a sensitive adjustment, or consult correction tables. With the Hartex compensating device, the essential factors can be set on a cam drum and the corrected value obtained without recourse to tables or trial and error adjustments.

Sole selling agent for these and other Hartex grinding machines in the United Kingdom is Rockwell Machine Tool Co. Ltd, Welsh Harp, Edgware Road, London, N.W.2.

Versatile Broaching Machines

500th "American" Unit built by Coventry Gauge and Tool Co. Ltd.

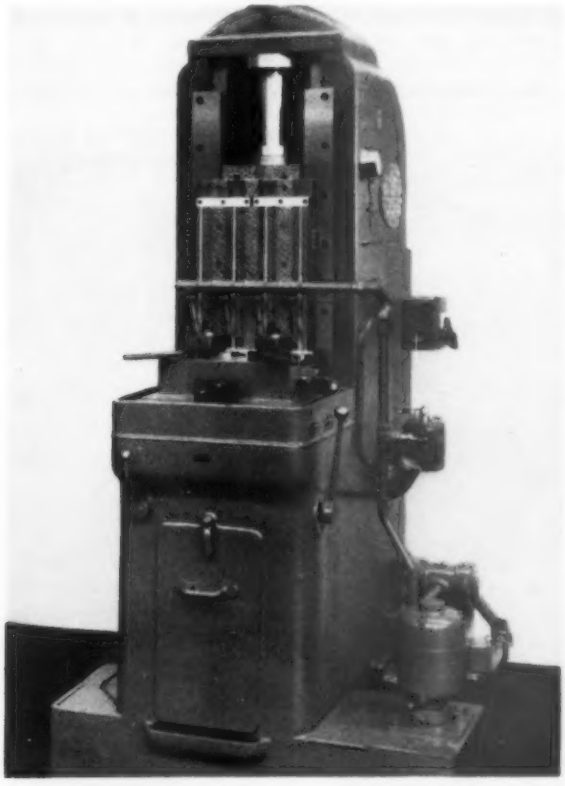
SHORTLY after World War II, the Coventry Gauge and Tool Co. Ltd. (Matrix) was granted a licence to manufacture "American" hydraulic broaching machines by the Sundstrand Machine Tool Co, of Ann Arbor, Michigan, U.S.A. Until then, these machines had been imported from the U.S.A. by Rockwell Machine Tool Co. Ltd, Welsh Harp, Edgware Road, London, N.W.2. When the licence agreement was concluded, this company remained the sole selling agent.

Recently the 500th British-built machine was completed and the occasion was marked by a ceremony at which it was formally handed over to a representative of the Ford Motor Co. Ltd. The actual tool, a Model T-8-24 three-way vertical broaching machine, is illustrated. It is the latest of many Matrix-built "American" machines supplied to the Ford Co. Others on order are yet to be built.

The machine will be used in the production of 105E engines for the Ford Anglia car. It will be delivered complete with the tooling and fixtures shown for simultaneously surface-broaching four location notches in the overhead valve rocker shaft. Coventry Gauge and Tool Co. maintain a full fixture and tooling design service, and a production unit. Broaches are manufactured by a special division of the Company at Ratby, Leicestershire.

A full range of "American" broaching machines is manufactured by the Company. Both horizontal and vertical models are available having stroke lengths up to 66 in. The larger versions of the horizontal machines can be fitted with outer support tables with rear broach carriage and automatic front support. All are suitable for both internal and surface broaching operations.

Set-up for broaching four location notches in overhead valve rocker shaft



Reverting to the machine illustrated, it is the smallest of a range of three type T models having respective capacities of 8, 10 and 15 tons. Complete with hydraulic power unit, with a 10 h.p. 260 r.p.m. motor, it occupies a floor space of 45 in × 64 in and overall height is 90 in. Normal operating pressure is 670 lb/in^2 and the oil reservoir in the machine base has a capacity of 38 gal. The coolant pump has a delivery rate of 12 gal/min from a 19 gal reservoir.

Applied to T-type "American" broaching machines, the term "three-way" explains the versatility of the type. Each is designed to be interchangeable to any one of the basic broaching methods — pull, push and surface. Whichever method is employed, adequate power and capacity is available to ensure smooth and efficient production. Cutting speeds of the broach are variable by means of a flow-control valve and fine adjustments of speeds are obtained against a graduated scale. Repeat readings are thus easily identified.

Various supplementary or auxiliary equipments are standardized for these machines. For pull-down broaching a retriever unit is available which suspends the broach clear during loading, lowers it into the pull head and then, after the finished work has been unloaded and the broach returned, lifts it again to the clear position. A retractable worktable can be supplied for surface broaching operations. This enables the fixture and work to be withdrawn automatically and thus facilitates unloading and reloading.

Left: Matrix T-8-24 "American" machine arranged for surface broaching

Machine Tool Research

New Applied Research Department Set Up by Alfred Herbert Ltd, at Coventry

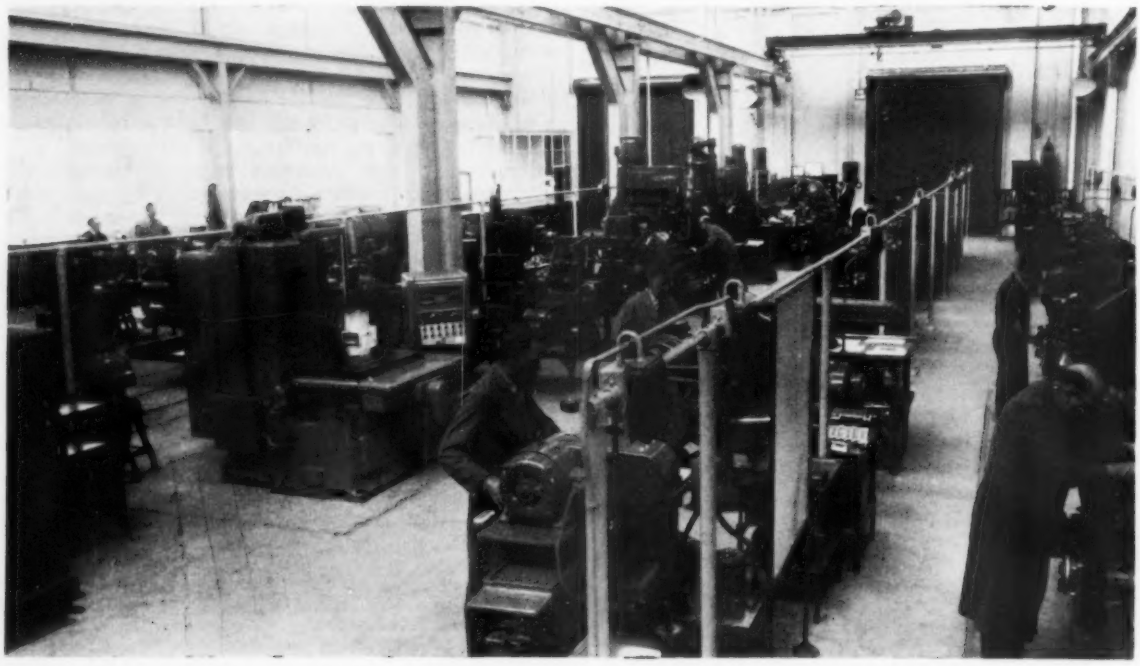
IN February of this year the establishment of a Machine Tool Industry Research Association was announced. Adequate support was received from the industry to secure a grant in aid from the Department of Scientific and Industrial Research and headquarters are being set up in Manchester. The need for such a corporate organization had long been recognized but in the past some opposition and much reluctance was encountered and little or nothing was brought into operation.

In view of the long history of the manufacture of British machine tools by relatively small family and private concerns, the deep-rooted traditions of sedulously acquired skills, slowly accumulated "know-how" and jealously guarded trade secrets are readily understandable. In the last half century the rising demand for machine tools, peaking in two world wars which occasioned rapid expansion of output and wide measures of co-operation, these traditions have been weakened. In more recent times, increased competition from countries pursuing a policy of rapid industrial expansion, and the threat of more intense competition, evident from the progress made in countries having a rigidly controlled economy and strictly centralized industrial planning, has had a marked influence on the British industry.

Under the changed economic conditions of today there are, of course, manifold influences—taxation forcing private into public companies, and small firms into large groups; the shortage of skilled labour; and the drain of skilled labour to the newer industries may be cited. Not unnaturally, the industry has been subjected to critical investigation. The Melman report to the European Productivity Agency of O.E.E.C, though still unpublished, is known to be severely critical. The Machine Tool Advisory Council of the Board of Trade appointed the Mitchell committee to study the Melman report and the industry. This committee could not accept many of the conclusions in the Melman report but found that the research programme in the industry as a whole was inadequate. There is but little doubt that these reports had a tonic effect on the industry.

In one section of the Mitchell report certain major companies were specifically excepted from the general finding of inadequacy. Although these companies were not named in the report, it would seem to be a reasonable assumption that the firm of Alfred Herbert Ltd, of Coventry, would be one of these noteworthy exceptions. Founded in 1889, and now the largest manufacturer of machine tools in the country, it has a continuous record of research and development and has been responsible for numerous innovations in design. Some of these developments were well in advance of the prevailing technique at the time of their introduction. To mention one instance, a screw machine was brought out in 1899. This was a fully automatic machine fitted with a magazine feed for automatic work handling. Another example was the launching of the Coventry self-opening diehead in 1901, a development that virtually halved the time required for screw-cutting on any machine to which it was fitted. The record of the Herbert Company in respect of technical innovation is impressive.

This section of the new department is equipped for building prototype machines, mechanisms, tools and fixtures for research work and testing



Erection shop in the research department. Here machines are built up and subsequently operated under the relevant controlled test conditions

Recently, a new, well-equipped, research department for the Company was officially opened by the President of the Board of Trade. The spacious modern building is sited at the main works at Coventry—the Company includes four factories and also four subsidiary companies—and will serve the entire organization. From this centre all mechanical and electrical development work will be integrated, extended, and controlled. Facilities are provided for building prototype machines and mechanisms, for testing new machines, tools, and fixtures, and for trials of new products under working conditions.

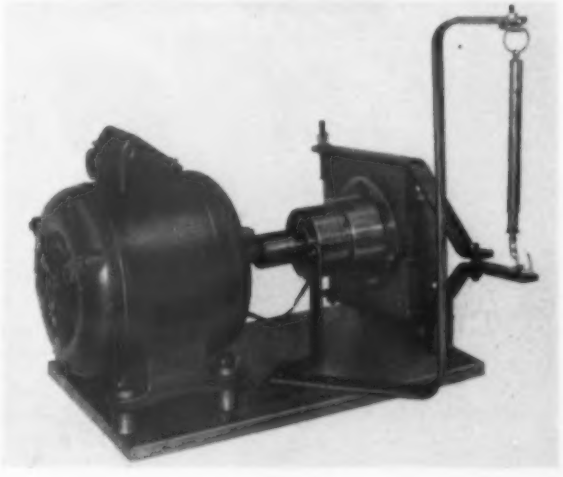
An electrical laboratory forms part of the department. In this, initial development work is carried out on electrical units and control systems for machine tools, diecasting machines, and plastics moulding machines. Control systems are then applied to actual machines for final development. Closely linked with the work of the research department are the machine design office, the tooling design office, the physical laboratory, the chemical laboratory, and the A.I.D-approved measuring department.

It is not without significance that the new centre is officially described as an "applied research department". This is characteristic of the Herbert organization which has continuously held, expressed, and put into practice, the view that the ultimate end product of the industry is not machine tools but industrial production. Its aim in research is towards any development that will assist industry in general to achieve production with the minimum waste of manpower, material, money, and time. An outstanding instance —it may, in fact, be regarded as a classic example—of this deliberately practical policy occurs in the Herbert No. 4 capstan lathe. Introduced in 1895, it won renown all over the world and has been subjected to virtually continuous research and development. It has, of course, been vastly changed in appearance, capacity, and performance, but the basic concept of its design is unchanged and still valid.

The programme of the new department is strictly not divisible, but for convenience it may be regarded as following two main streams. First, research into the fundamental problems of the machine tool maker; initial accuracy, maintenance of accuracy, the causes and cure of noise and vibration, the reduction of friction, the effects of thermal expansion, and the conflicting relationship of cutting materials and the materials to be cut. The second will be concerned with more immediate developments in the fields of metrology and production; work-holding and work-loading devices, pre-set and quick-change tooling, automatic operating-cycle controls, positioning devices, reduction of setting and idle times, and ergonomics in general.

Following these aims, liaison will continue to be maintained with national and other industrial research establishments for information of a basic character, and with other

On this rig electric clutches are tested for torque capacity and wear



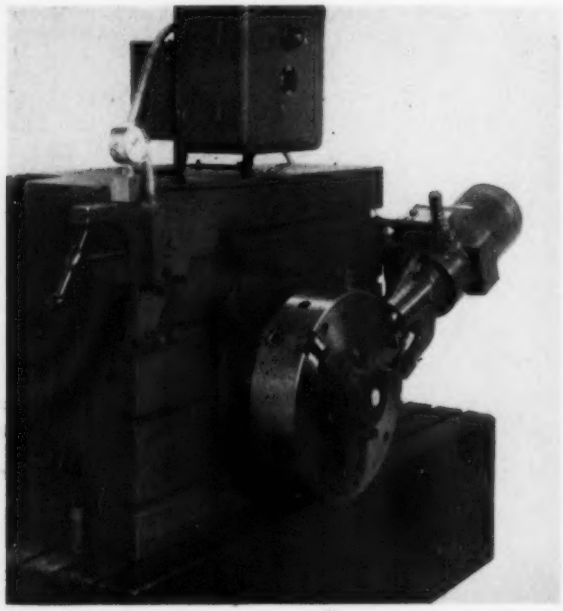
The electrical laboratory where initial development of control units and systems is carried out

industrial organizations on the application of their own specialized developments.

With such a large and widespread organization, the Company is in intimate contact with manufacturing industries and enabled to analyse trends in production and, by applying information received, assess current or impending problems, and investigate possible solutions. The Company is one of the pioneers in the policy of maintaining a staff of qualified engineers to which customers can submit their production problems. Enquiries for machine tools, averaging 18,000 per annum, come from agents and associates in 61 countries, from 10 branch offices in the United Kingdom, from 27 travelling production consultants, and direct from nearly 20,000 customers.

On the opening day of the new department approximately one-third of the exhibits in the mechanical section showed complete machines undergoing development to increase production. A substantial proportion of the machines incorporated experimental electronic programme-control equipment. Many research, development, and test programmes can be run concurrently with others and on the opening day 41 projects were undergoing investigation.

Rig for testing a power chuck wrench. A torque gauge indicates the grip



Testing of static switching control units, in the electrical laboratory

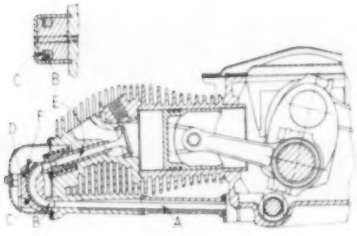
CURRENT PATENTS

SELECTED ABSTRACTS OF RECENTLY ISSUED SPECIFICATIONS

Overhead valve actuation

A DEVICE is described which is designed to replace the rocking member in conventional push-rod operated overhead valve gears. Reciprocating movements of a push-rod A are transmitted to a valve E by a curved bar B, of rectangular section, one end of which is in contact with the push-rod, and the other with the tip of the valve stem. This bar is bent through an arc of approximately 160 deg and slides in a groove in the side of a block D at the top of the cylinder head.

The upper, or concave, face of the groove can be lined with a strip C of bearing metal, since it is this surface that has to withstand the forces imposed by the valve spring and the push-rod. Adjustment of valve clearances is effected



No. 861291

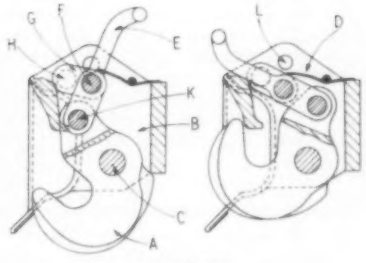
by shims placed between block D and the cylinder head. Oil for the bearing strips is fed from the passage F drilled in D.

In designs where two valves are parallel the curved grooves can be sited at each end of a common block D, and provision is made for the fitting of a cover or strap to pass over the block and enclose the grooves, thereby retaining the bars. The advantages claimed for the curved bar principle of valve actuation are improved lubrication, low bearing pressures and, because of the provision of more metal in the upper regions of the valve guides, better heat flow from that area, especially in air-cooled engines. *Patent No.* 861291. *Humber Ltd. and L. J. Shorter.*

Towing hook

IN this device, which is a towing hook for a heavy tractor vehicle, the hooking component is pivoted, and can be locked in either an open or a closed position by a lever that has a toggle action. As can be seen from the illustration, the hook A is pivoted on pin C in the bracket B, which is fixed to a rearward facing surface on the towing vehicle. Above C, in an extension of the hook, is pin K, to which is connected the lower end of lever E.

There is another pin F through lever E, a short distance from K, and it is connected to a pivot pin H in bracket B by a short



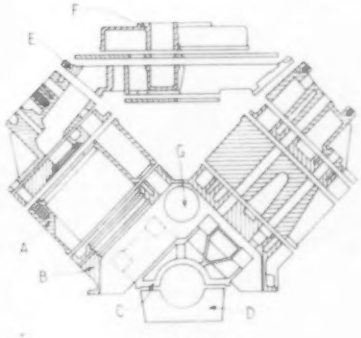
No. 863919

link G. When lever E is pushed forward, the hook is opened, and its upper extension abuts against part of bracket B. When pushed back, the lever abuts against the same part of the bracket, and the hook is locked in the closed position.

In addition to the toggle action, two other features assist in the functioning of the device: a spring D which presses down on the forward end of link G; and hole L, in bracket B through which a pin can be passed to hold the hook in the closed position. *Patent No.* 863919. *Ringfeder G.m.b.H. (Germany).*

Built-up engine unit

MANUFACTURE of light alloy cylinder block assemblies by the die casting process is difficult because of the complex shapes of the water passages. In this specification, it is suggested that the difficulty is obviated if components are made separately, and subsequently bonded together by a thermo-setting agent such as an epoxy resin. In the V-eight engine



No. 862337

illustrated, two cylinder blocks A are bonded, one to each of two faces at right angles to each other, on a crankcase member B.

There are two cylinder heads, each comprising two parts bonded together at a face parallel to the cylinder joint face. Beneath the crankcase member, and cast integrally with it, are transverse stiffening ribs, between cylinders, and on them are seated the supports C for the crankshaft bearings. Each of these supports has two lugs, the first of which is to the rear of a crankcase transverse rib, and facing towards one bank of cylinders, and the second is to the front, and facing the other bank.

This engine assembly is held together by long bolts which are parallel to the cylinder axes and which are inserted through holes in the heads and blocks, to screw into tapped holes in the lugs on C. The main bearing caps D are bolted to the underside of supports C. Holes G, for the camshaft bearings, are set high in the stiffening ribs of B.

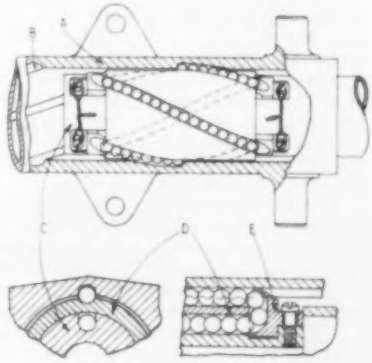
A composite manifold assembly F, on top of which the carburettor is bolted, is common to both banks of cylinders, and forms a bridge between the heads. Its components are bonded together, and the main one has two flanges E, whose joint faces are approximately at right angles to each other, and which are bolted to the cylinder heads. It is claimed that extremely high compression ratios can be used in an engine of this form of construction. *Patent No.* 862337. *General Motors Corporation (U.S.A.).*

Helical spline

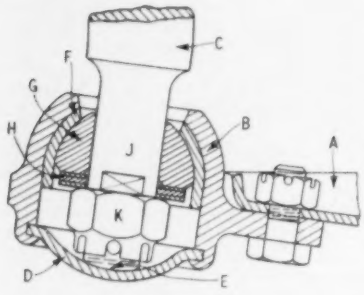
THIS device, by virtue of its very low friction losses, can translate rotary into linear motion even when the helix angle, relative to the axis, is small. Also, for a given torque capacity, its overall diameter is less than that of a conventional helical spline assembly. A cylindrical body A, which is constrained to have an axial motion, embodies external mounting flanges and trunnions of unspecified purpose, and has equally spaced helical grooves B in its bore.

Enclosed by the body A, and constrained to rotate, is a shaft C; and interposed

No. 862661



between A and C is a short sleeve D which is fixed to C, but separated from A by a small clearance. Helical grooves around the outer face of D correspond to those in A, and are of a depth and shape such that steel balls are free to roll in them without excessive radial or circumferential move-



No. 859199

ment. There are also helical grooves around C, enclosed by the bore of D, but these are larger in section and of opposite hand to the others, so that the balls deflected radially inwards over the end of the sleeve by guide blocks E, can recirculate freely. The guide blocks also serve to lock sleeve D to shaft C. They are screwed to C, and the drilled heads of the screws are wired, for security. *Patent No.* 862661. *General Motors Corporation (U.S.A.).*

Suspension ball joint

IN some independent suspension systems of the double wishbone type, the outboard bearings of the wishbones are ball and socket joints and also serve as the king pin bearings. It is customary for these joints to embody replaceable ball studs, which are fixed to the vertical extremities of the hub carrier. This patent specification concerns a hub carrier having extremities of circular section, over which the part-spherical, replaceable seatings fit. An additional feature of this design is that some hub carriers that do not normally incorporate ball and socket joints can easily be adapted if the extremities of these carriers are of circular section.

The lower extremity J of a hub carrier C is of circular section and has a short threaded portion at the end. A ring G, of approximately hemispherical shape, fits over J, with its plane side facing downwards, and is retained by a nut K, which is pinned to prevent rotation. The tip E of the threaded portion of J is also of part-spherical shape, and its centre of curvature is common to that of ring G, so that the two faces duplicate the upper and lower faces of a ball stud.

A socket member B, which is bolted to wishbone A, has integrally formed in it the upper part-spherical face of the socket, in the centre of which is the hole through which passes the extremity J. Between this face and that of the ring G is a liner F. To complete the enclosure of this assembly there is a retainer plate D, with a part-spherical depression, which bears against the tip E and is held in place by the peening over of a rim on B.

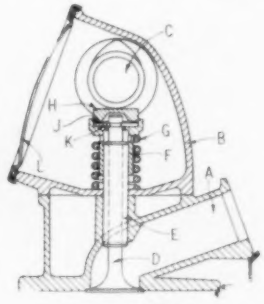
Preloading for this joint is provided by a sandwich ring H, interposed between G and K: this ring comprises a layer of rubber interposed between two steel washers, and it is constrained against rotation. Among the other advantages of this arrangement are: misalignment between G and K has no undesirable effects, transmission of shock and vibration is minimized, and wear is automatically taken up. An alternative suggestion is made that K can be a domed nut whose part-spherical end bears against D. *Patent No.* 859199. *Viktor Langen (Germany).*

Overhead camshaft valve gear

IN this design of an overhead camshaft valve gear the cylindrical outer surface of the valve guide acts as a guide for the cam follower, to reduce the effects of side thrust imposed by the cam. The illustration is a sectional view of part of a cylinder head, showing a poppet valve D which slides in a vertically disposed valve guide E. Approximately half of this guide projects upwards into the cam chest B, the lower half being pressed into the cylinder head and projecting, in the conventional manner, a short distance downwards into the port A.

The cam follower F is in the form of an open-ended, flanged cylinder, the flange being at the upper end and acting as the top abutment for the valve spring G. Above the flange is the slotted plate K which registers in a groove at the end of the valve stem and is thus the valve retainer. In contact with the cam C is a cap H, which rests on top of the flanged part of F and is radially located by a lip on the flange.

There is a shim J underneath the cap H, the thickness of which must be chosen to suit the desired valve clearance. Access to each valve assembly is through an aperture in the wall of the cam chest, and closure of this aperture is effected by a



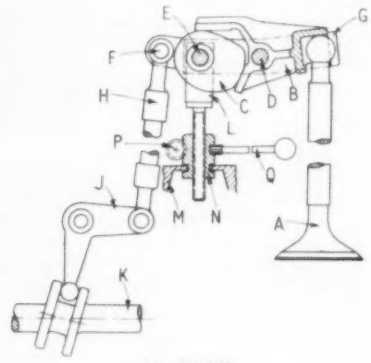
No. 860983

cover L. Provision is made in the patent specification for an alternative method, by tapered cotters, of valve retention. *Patent No.* 860983. *Ford Motor Co.*

Desmodromic valve gear

CURRENT desmodromic valve systems, in which valves are both opened and closed by positive cam action, invariably embody overhead camshafts, but arrangements of this type are usually too costly to be considered in mass-production vehicles. Described in this patent specification is a desmodromic sysem for application with a camshaft sited conventionally in the crankcase, and which is equipped with a device for the adjustment of the stroke and timing of valve operation. In the illustration, a swash-plate is shown as the actuating mechanism, but provision is made in the specification for alternative actuation by an eccentric circular cam on camshaft K, in conjunction with a ring-shape follower.

The end of one arm of a bell crank J registers in a groove around the swash plate, and a reciprocatory motion is transmitted through push rod H to a knuckle joint F which is at the end of an arm integral with a cam C. This cam is pivoted on pin E, and it actuates a rocker B which



No. 861369

is pivoted on pin D. The rocker, in turn, is connected to poppet valve A, the end of whose stem is of part-spherical shape so that it fits in a horizontally disposed, slotted cup-shape cavity: the sides of the cup transmit the opening and closing motions to the valve.

At the other end of the rocker there are two faces, approximately at right angles to each other, to contact the cam. Oscillations of the cam alternately open and shut the valve, and, by virtue of the eccentrically mounted pins E and D, adjustment can be made to minimize the free play between cam and rocker. These two pins are mounted on a lever G, the pivot of which is mounted on the cylinder head with its axis in line with the centre of the ball-end of the valve stem; the end of the lever, at E, is adjustable for height.

This adjustment has the effect of varying the valve timing and stroke, and can be controlled either manually or automatically. One of the suggested systems of control is illustrated, in which pin E is enclosed by yoke L which has a threaded extension whose height is determined by a nut N. The nut is set in the cylinder head M, and is turned either by a speed-controlled worm mechanism P, or, in the case of a constant-speed engine, by a manually-operated lever Q. *Patent No.* 861369. *Ferdinand Porsche (Germany).*

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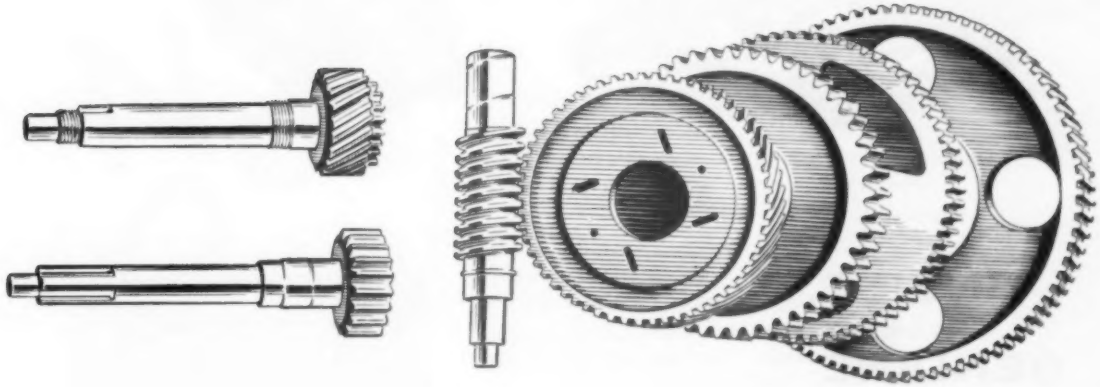

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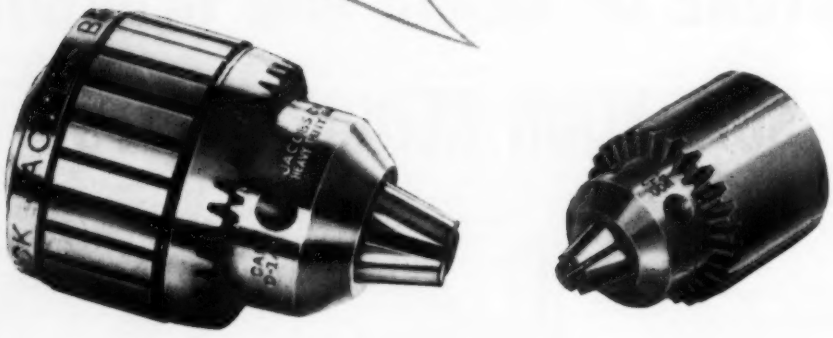

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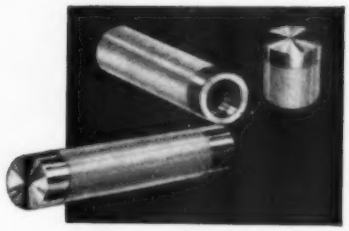

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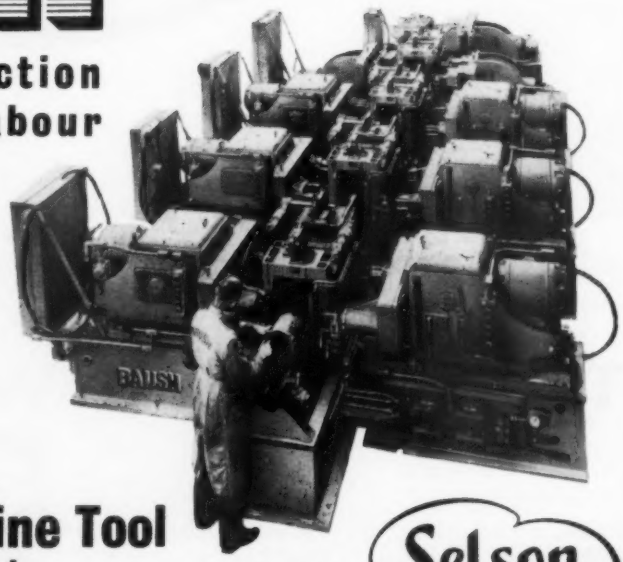

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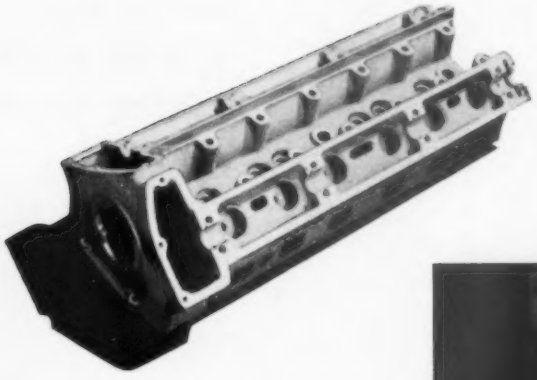

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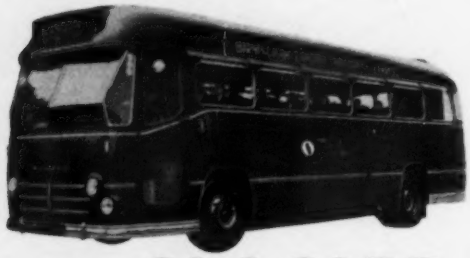

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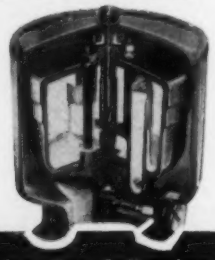

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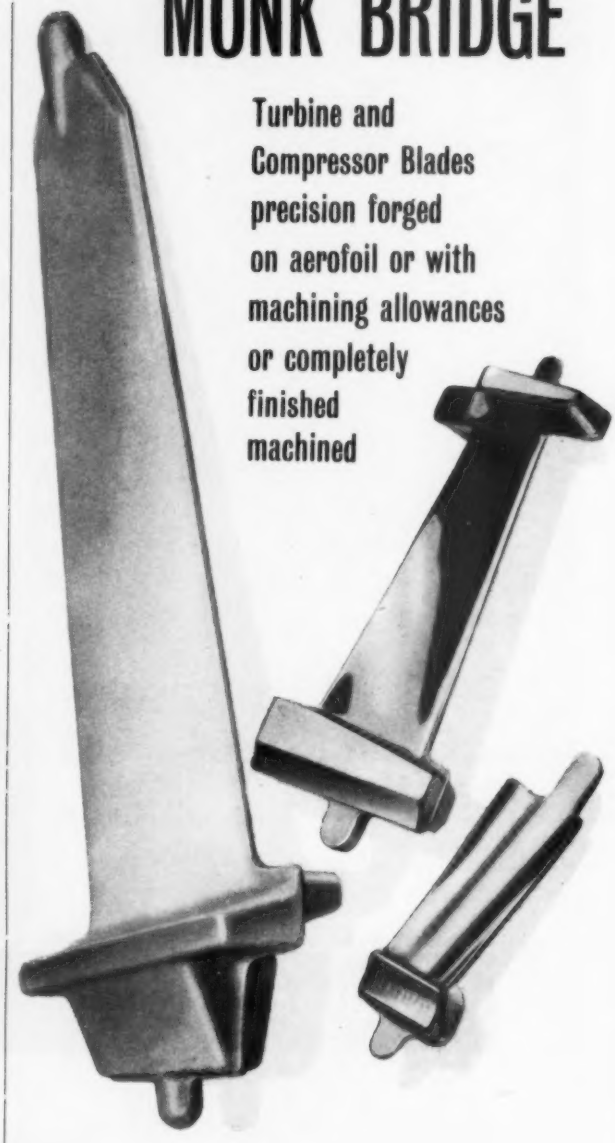


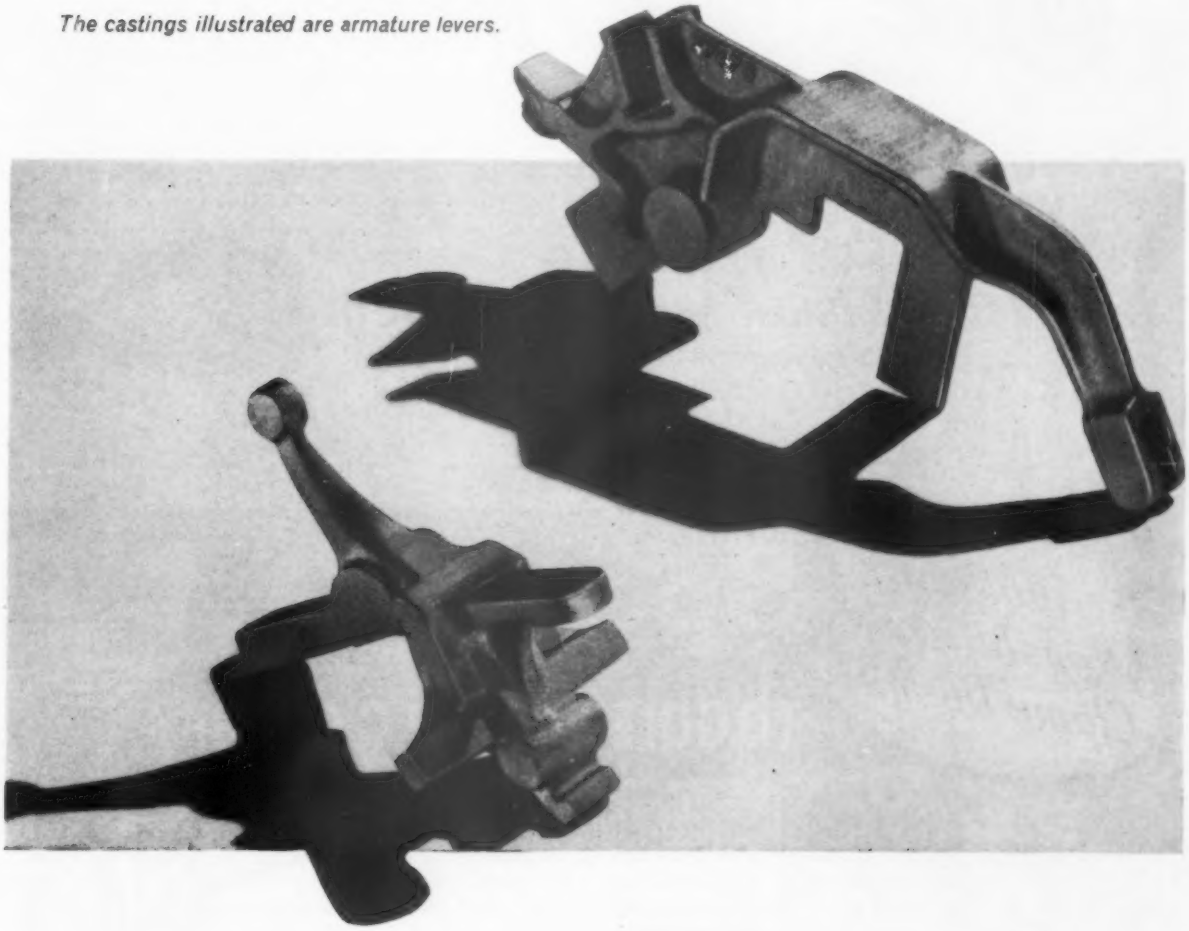
We are the largest and best equipped producer of precision forged blades to very close limits of dimensional accuracy and surface finish, and to the highest metallurgical standards. Turbine Blades in a full range of heat and creep resisting steels and Nimonic alloys. Compressor Blades in aluminium bronze, high creep stainless steels and titanium alloys. Also: precision forgings in the newer or difficult-to-machine metals for nuclear, missile, chemical, surgical and other equipment.

MONK BRIDGE IRON AND STEEL COMPANY · LEEDS 12
Branch of Daniel Doncaster and Sons Ltd., Sheffield

Sections too delicate for steel castings; service requirements too exacting for ordinary cast iron or non-ferrous castings; fabrications too expensive and not consistent enough in form and quality: the answer to such a problem may well be a **GF** Malleable Casting. One of the most significant of the many impressive figures relating to **GF** Malleable Iron is its very high yield point in relation to ultimate tensile strength—as high as 65%. Our advisory service is freely at your disposal.

Some jobs are beasts

The castings illustrated are armature levers.



GF MALLEABLE CASTINGS

A Member of the GEORGE FISCHER group

BRITANNIA IRON AND STEEL WORKS LIMITED
BEDFORD Telephone: Bedford 67261 **ENGLAND**

Facts and figures are yours for the asking. Please write or 'phone.

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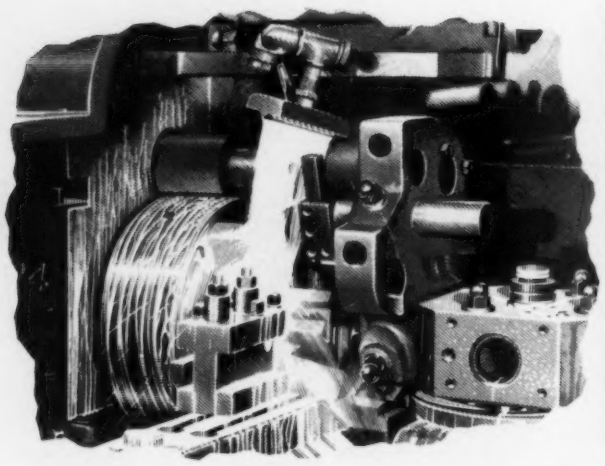


Who fixed the production target ?

Not every machine operator has stars in his eyes! For the rest, a mundane sequence of speed changes, feeds and cuts produces a lot of little parts that other people want. And the easier the ways of doing this, the happier are both a bonus-seeking worker and a budget-minded management. In this idyllic atmosphere, it seems downright unsporting to drop a spanner in the works—and a whacking big one at that! Frankly, we dont always agree that the way things are done in metal cutting are necessarily right. Producing such good cutting fluids—and so many of them—tends to bias our outlook of course but have you ever tried, at one and the same time, to pull the wool over the eyes of a metallurgist, a planning engineer, a graph-watching production assistant and — bless them — a cost-conscious purchasing officer? It is just impossible. The fact is Fletcher Miller cutting fluids are on good terms with all these gentlemen—and those worthy fellows at shop floor level who actually use them. Relieve yourself of one headache by consulting us about all your production oils. The cure is quite painless. Call in the experts.

choose **FLETCHER MILLER** *cutting fluids*

FLETCHER MILLER LTD., HYDE, CHESHIRE Telephone: HYDE 3471 (5 lines). Telegrams: EMULSION, HYDE

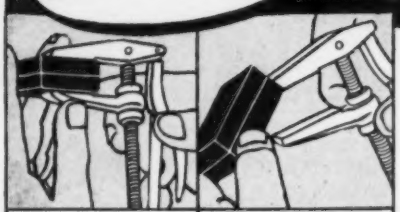
CF 136

Another Revolution in Clamp Design!

Speetog

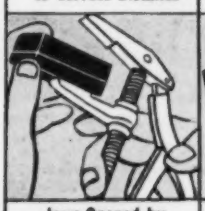
REG° TRADE MARK

TOGGLE ACTION 'C' CLAMP



Lower Jaw Adjusted to Correct Distance

Workpiece Removed, Lower Jaw Adjusted for Pressure

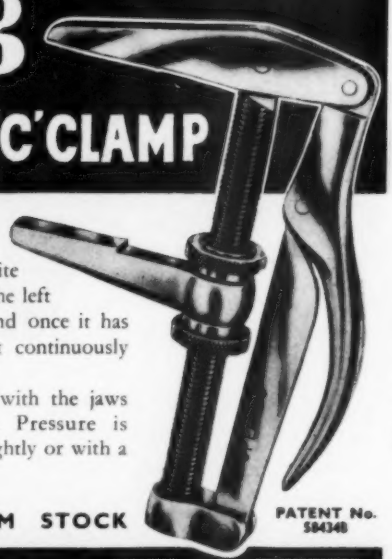


Jaws Opened by Trigger Handle to Insert Workpiece

Trigger Handle now Locks Jaws on Workpiece

The Speetog Toggle "C" Clamp is a self-locking tool which locks on to the work and holds it firmly gripped after quite simple adjustment. The illustrations at the left show how simple it is to set the tool and once it has been set to a definite size it will repeat continuously with the same pressure.

The tool will grip up to $3\frac{1}{2}$" capacity, with the jaws parallel at all points of adjustment. Pressure is adjustable, so that the Clamp will grip lightly or with a heavy pressure as required.



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Speed Tools Ltd

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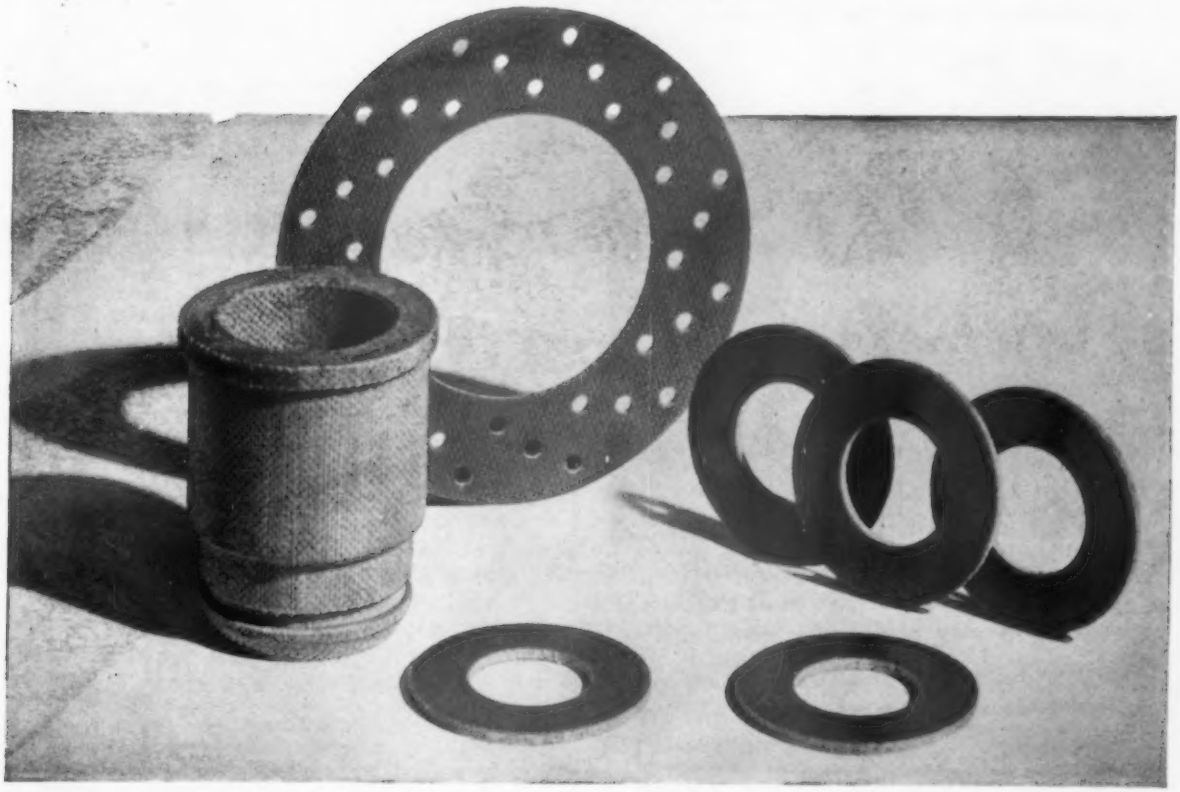
Have you discovered TUFNOL?



Tufnol is an extremely versatile material with many potential applications in the automobile industry. It is light but strong and hardwearing, resistant to corrosion, and requires little or no lubrication. Tufnol is an excellent electrical insulator, it machines easily with ordinary tools and resists deterioration in storage. In short, Tufnol is a single material, incorporating the virtues of many.

These virtues have already been recognised by Rover, Jaguar and Burman & Sons, amongst others, in the selection of Tufnol for small components giving vital service. The Rover Co., for instance, use Tufnol thrust washers in the rear axle assemblies of their cars and Land Rovers. Jaguar cars have Tufnol washers and bushes in the gearbox and linkage, as well as washers between clutch and brake pedals. And Burman & Sons have this to say about their Tufnol steering column bushes: "Tufnol gives a good bearing for the situation which has no positive lubrication; the bushes are light and they do not corrode".

There are twelve brands of Tufnol. All are laminated plastics; each with pre-determined properties, formulated to satisfy specific requirements, and each is available in sheets, rods, tubes, angles and channels.

Your local Tufnol Branch Office will gladly provide you with further information and technical advice.

TUFNOL

(REGD. TRADE MARK)

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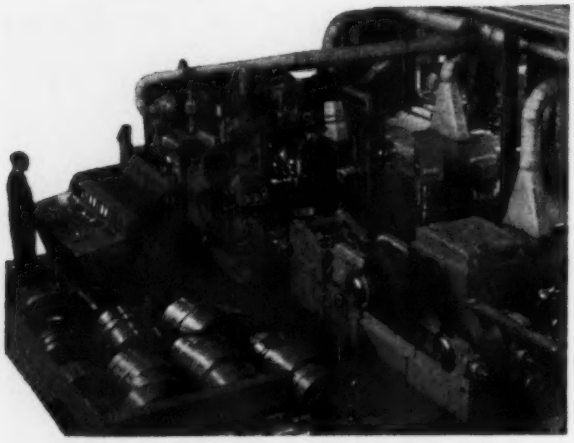
433

Now even closer tolerances on Habershon cold-rolled strip

New, fully-automatic electronically controlled plant in operation at Holmes Mills



Now you can depend even more on the traditional 'quality in quantity' of Habershon steel strip.

Faster production: micro-measurements more consistent than ever before: tolerances even closer than those required by the strictest specification—all this is made possible at Habershons by the recent installation of completely automatic plant.

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GRADING: *17 precise grades from 9H to 6B*
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TRY TURQUOISE DRAWING LEADS
AVAILABLE FROM 2B TO 6H

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A WORLD OF VIBRATION

Vibration technology is a comparatively new development in the field of environmental engineering. Its applications in measuring metallurgical stresses and strains, in simulating fatigue to destruction point, are fairly well-known, but even the present scope is far wider than these. The potential is immense to a degree which possibly outreaches that of any other applied science. It is even possible that there is much to be rediscovered, for the histories and mythologies of ancient civilizations abound in references to physical motion achieved through sound vibrations. The destruction of the walls of Jericho is an example; and it has been suggested that the Pyramids' vast masonry was elevated by similar means. But fascinating and perhaps revealing as that line of inquiry may be, this report will deal principally with the immediately practical uses of vibration testing.

From eyes to motor cars is an apt and related part of the applications range. Taking the first and uncomfortably picturesque example, an incidence of severe headaches and impaired vision suffered by transport drivers led to tests with vibration equipment. These showed that through vibration on certain road surfaces, the drivers' eyes were being literally bounced back and forth in their sockets.

MOTOR VEHICLE INDUSTRY

Car bodies and their attachments are subject to mechanical and other vibrations transmitted through suspension systems. What with wear and tear and varying concern for maintenance, the noises which can result are an age-old problem at the service station. The drumming heard by the owner 'under the back seat somewhere' is usually non-existent in normal workshop testing; out on the road it's audible but locating it is a tedious and uneconomic guessing game.

Yet further complications arise out of the fact that the vibration source may be far removed from the apparently offending component or structure.

We have a compact generator/oscillator/power amplifier combination by which all the running vibrations can be simulated *in the workshop* and the noise source accurately and quickly located. Similar equipment is used by car manufacturers so that vibrations can be compensated or designed out.

ROAD CONSTRUCTION

Roads, too, can be investigated with vibration equipment. An applied vibration is picked up at a distance, on an oscilloscope. The signal time and strength factors vary according to the nature and thickness of the surface and subgrade materials. By these readings it can be determined whether or not the construction is according to specification. Periodic tests will reveal the extent of any deterioration. In research, the behaviour of roads under various traffic conditions can be established and the information used in framing specifications for new roadworks.

AIRCRAFT INDUSTRY

In the aircraft industry, vibration testing has long been a vitally important technique. Bearing in mind the possible outcome of the failure of quite small components, vibration problems in land vehicles and structures pale into comparative insignificance. Goodmans equipment is widely used to test dynamic models . . . even whole aircraft . . . and on the multiplicity of instruments and electronic apparatus.

The tremendous power and complexity of rocket-propelled vehicles set still more-exacting requirements and for these Goodmans are producing special generators.

OTHER APPLICATIONS

The miscellany of these is far too extensive to catalogue here, but the following will serve to demonstrate the scope.

In fatigue testing, vibration generators provide wide range and prolonged consistency.

Chemical and bio-chemical research are served by our smallest generator, the V47, in mixing, emulsifying and the measurement of interface potentials. It has been used also to simulate nerve signals and to assess vibration effect on living tissue. Experiments show that physical vibration and 'white noise' have anaesthetic properties.

Vibration equipment is used in the rubber, plastic and textile industries, as an aid in establishing the materials' mechanical properties.

Experiments in the machine tool industry have shown that small and carefully controlled vibrations can, in fact, improve stock removal, surface finish and minimize the effect of certain operations upon molecular structure.

This is inherently a world of movement. Everything vibrates within itself and often as an entity. These forces can be observed, reproduced, supplemented. There must therefore be many functions for our vibration equipment which even we can only guess at . . . and even more as yet unthought of. Name your problem; consider what may be done better, faster, more economically . . . what may be done perhaps for the first time, with the help of vibration equipment. It's more than likely that the means to the end is ready-made.

Goodmans electro-mechanical vibration generators, the largest range in Europe, comprise:

TYPE	PEAK THRUST
V47	2 lb
390A	17 lb
790	35 lb
8/600 Mk.II	300 lb
VG108 Mk.II	5,300 lb
VG109 Mk.III	18,000 lb

There is available a corresponding range of oscillators and power amplifiers

GOODMANS
the vibration specialists

GOODMANS INDUSTRIES LTD. AXIOM WORKS, WEMBLEY, MIDDLESEX ENGLAND Wembley 1200 (8 lines) Cables: Goodaxiom, Wembley, England

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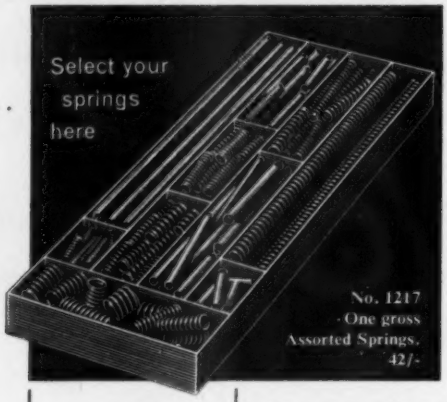
GD659

EXPERIMENTAL SPRINGS?



That spring you want . . . in a hurry . . . where is it? Pick what you want when you want it from TERRY'S BOXES OF ASSORTED SPRINGS—our fine range of small boxed assortments of experimental springs. We can show you only a few from the range here. Send a postcard for our full list—and if ever you're stuck with a spring problem send it along to our Research Department—they'll gladly help you out.

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Three dozen Assorted Light Expansion Springs, suitable for carburettor control etc. 15/-

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Cut Production Costs with Terry's Wire Circlips. We can supply immediately from stock—from ¼" to ½"

Looking for good Hose Clips? Send for a sample of Terry's Security Worm Drive Hose Clip and price list.

Have you a Presswork problem?
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- *Perfect alignment of centres*
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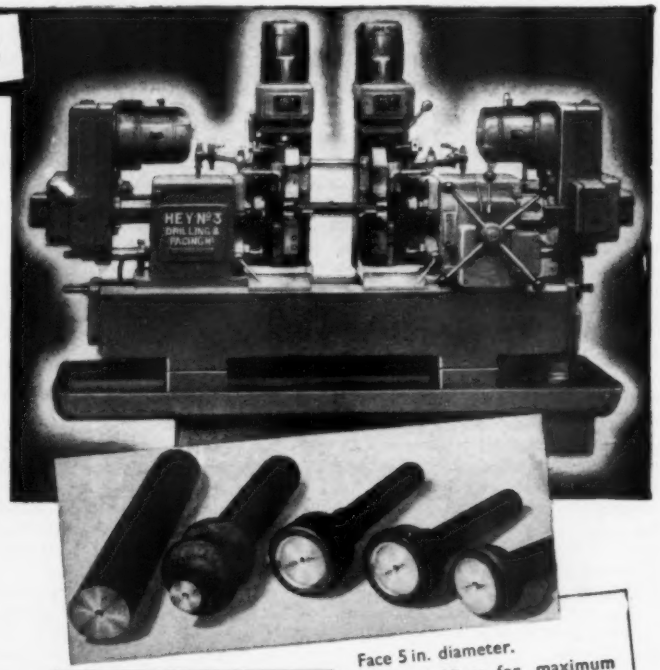
- *Eliminates subsequent facing down to centres or recentring*



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COVENTRY PHONE: COVENTRY 88641

We also manufacture Rotary Cam and Profile Milling Machines, Short Thread Milling Machines, Multiple Drilling Heads and Machines, Tapping Machines, Gear Tooth Rounding Machines, Special Machine Tools for High Production.

Face 5 in. diameter.
Standard Vices for maximum bar capacity of 6¼in. or 8in. diameter.
Minimum length handled, 3 inch.
Standard bed length to take work up to 24 in., 48 in., 72 in., or 108 in. long.

Here will soon be the new, up-to-date Brymbo Cogging Mill. From it will come low alloy and special carbon steels, including silico-manganese, in billet sizes up to 7″ square

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ANTI-VIBRATION

UNIT DESIGNERS LINK UP WITH BRITISH RUBBER MANUFACTURER!

Phoenix and Getefo will make a new dynamic approach to your vibration problems

Great news for British manufacturers! Phoenix are now producing rubber to metal bonded anti-vibration units which are designed by Getefo, acknowledged leaders in anti-vibration engineering. Getefo, or to give them their full name, Gesellschaft Fur Technischen Fortschritt MBH of Koblenz, pioneered the study of the dynamics of anti-vibration problems. Now, in this new association with Phoenix, the knowledge gained in their researches is made available to British industry.

Measuring the internal temperature of the rubber of an anti-vibration mounting, during dynamic testing.

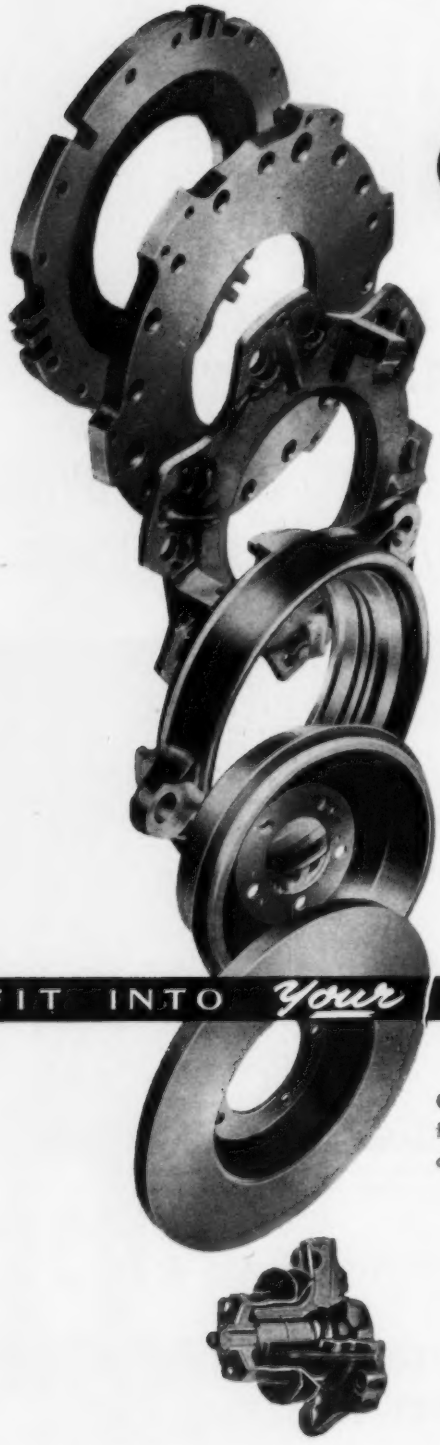
If you make a product which is subject to vibration, Phoenix can help you!

PHOENIX

RUBBER TO METAL BONDED ANTI-VIBRATION UNITS designed by Getefo

Phoenix Rubber Co. Ltd. Slough, Buckinghamshire. Telephone: Slough 22307/9

OA/9822



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. . . occupy a very special place in the motor industry, many special places to be exact. Designed and precision engineered to ensure economy of operation and a long service life, they "fit" into most assemblies.

Oil Pumps, Water Pumps,
Steering Idlers,
Clutch Plates,
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Brake Drums, Brake Discs,
Push Rods, Ball Pins,
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FIT INTO *Your* SCHEME OF THINGS

Concentric specialists in the design and manufacture of Oil and Water Pumps, have achieved a new high standard of performance and production in this field.

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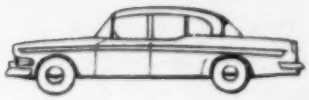
...at HUMBER LTD.



EFCO and ROOTES craftsmanship

With the constant demands for more productivity, is it inevitable that quality must be sacrificed to expediency? Fortunately for discriminating buyers, Humber say 'No' and support their view by installing batteries of Efco heat treatment furnaces to help increase their output *without* detriment to ROOTES Craftsmanship.

Used for processing gearbox components, crown wheels and pinions, these furnaces are the practical end-product of the most up-to-date design thinking. The furnaces all have automatic handling and programming equipment to speed production and cut operating costs. Furnaces for gears have an enclosed hot-oil quench to ensure close dimensional control. Furnaces for crown wheels have special holding chambers to give precise control of cooling and carbon diffusion cycles prior to press quenching.

Humber Cars have a reputation for quality. EFCO furnaces are helping to maintain that reputation.

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Associated with Electro-Chemical Engineering Co. Ltd.

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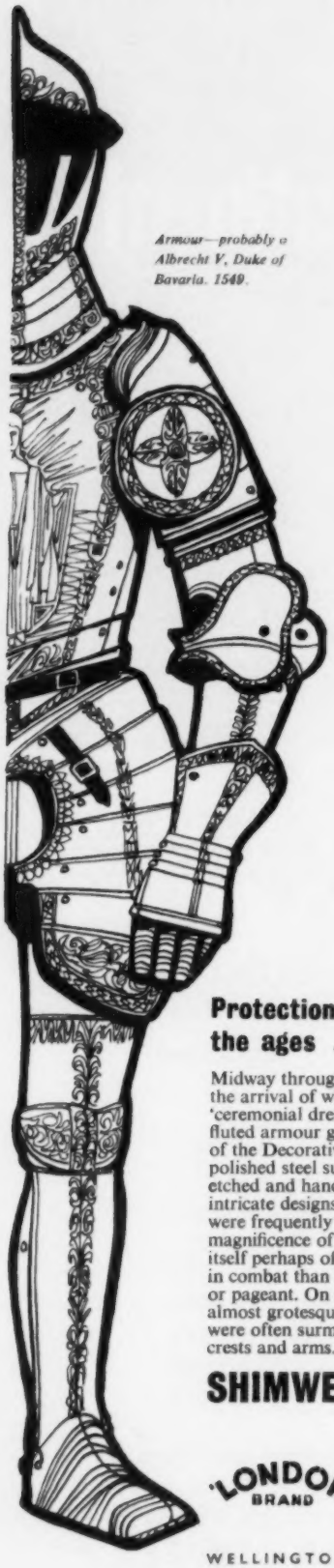

Armour—probably of Albrecht V, Duke of Bavaria. 1549.

Protection through the ages . . . 4

Midway through the 16th Century saw the arrival of what might be called 'ceremonial dress uniform'. Ornamentally fluted armour gave way to the splendours of the Decorative Period, when the polished steel surfaces were superbly etched and hand-engraved in most intricate designs. Gold and silver inlays were frequently used to add to the magnificence of armour of this time, in itself perhaps of less value as a safeguard in combat than as an attraction of parade or pageant. On such occasions, helmets, almost grotesque in their size and form, were often surmounted with elaborate crests and arms.

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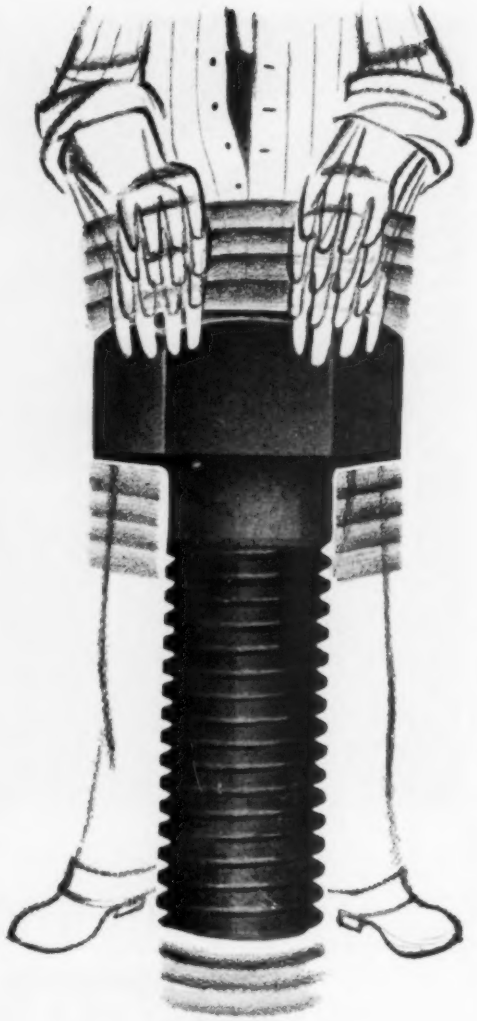

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Pneumatic tools are an obvious application for Lanarkshire High Tensile bolts. But there are many more subtle situations where this bolt's extra strength is employed to advantage. Machine tools, bridges, motor cars, cranes....wherever stresses and strains are to be withstood—Lanarkshire H.T. bolts and setscrews withstand. If your product needs extra strength at vital points—why not contact Lanarkshire? From 45—75 tons in R, T and V grades, Lanarkshire offer good delivery in B.S.1083 (Whitworth and B.S.F.) and B.S.1768 (fine and coarse) threads.

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TEC-ELEMENTS Biggest ever filtration area, most effective filtration, longest working life . . . best engine protection. Recommended and fitted as original equipment by the vast majority of British car manufacturers.

TECALEMIT RIBBON FILTER ELEMENTS Finest filtration at lowest cost of air, water, petrol, diesel and fuel oils, lubrication, hydraulic — just about every fluid you'd like to mention.

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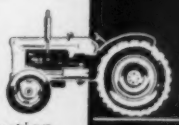
The BRD organisation has been built on the ability to maintain high standards of precision for quantity production. In every sphere of transport, more and more manufacturers are turning to BRD for the answer to their problems; crankshafts, constant velocity joints and transmission equipment for cars and tractors, turbine blades for aircraft engines and ships, all form part of BRD service to industry



BRD

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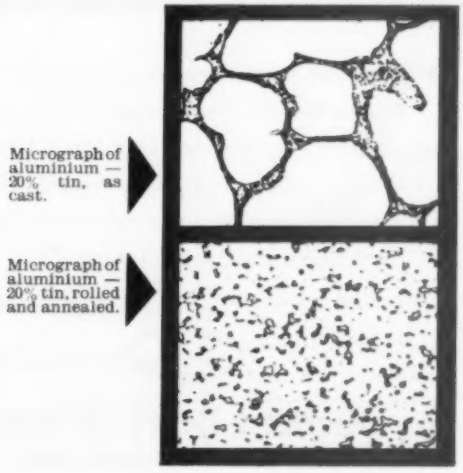
Glacier Reticular Tin-Aluminium on Steel

Reticular tin-aluminium, as bonded to steel for high load-carrying capacity engine bearings, is an aluminium alloy, containing 20% tin and 1% copper, worked and heat-treated so that the tin is continuous only along grain edges, but not along grain faces, as is the case when this alloy is in the "as cast" condition. Working and heat-treatment enable the aluminium grains to bond into a continuous aluminium phase whilst the tin, although not distributed over the grain faces, is still a continuous network structure.



Micrograph of aluminium — 20% tin, as cast.

Micrograph of aluminium — 20% tin, rolled and annealed.

The latest development in Plain Bearings, defined above in technical terms, offers manufacturers and private motorists—

New standard of load-carrying capacity.
Exceptional life.
Compatibility with conventional crankshaft materials.
Resistance to corrosion attacks.

It has now been adopted by—
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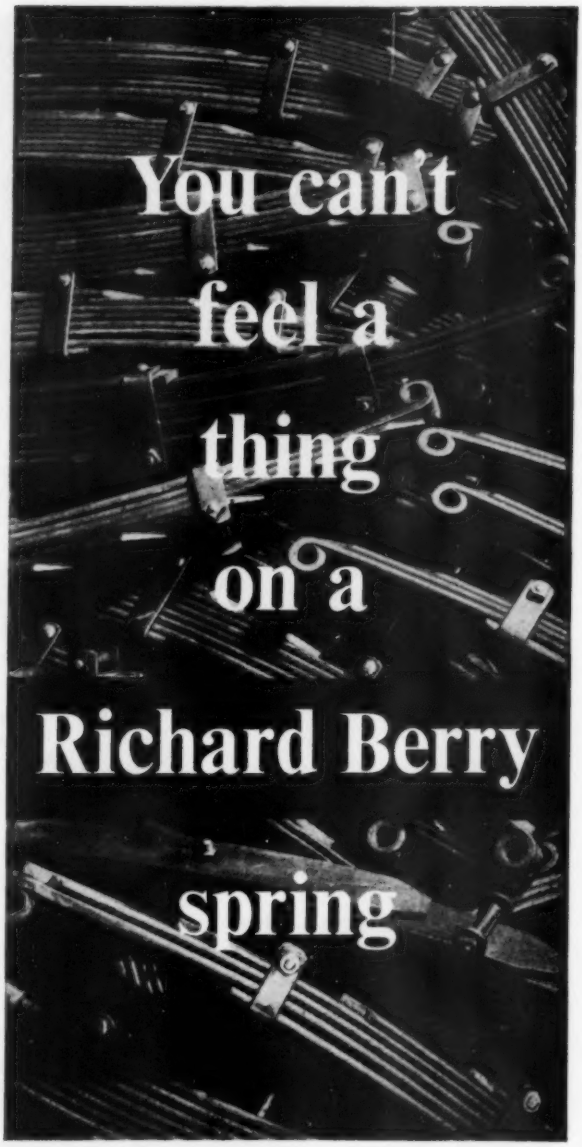

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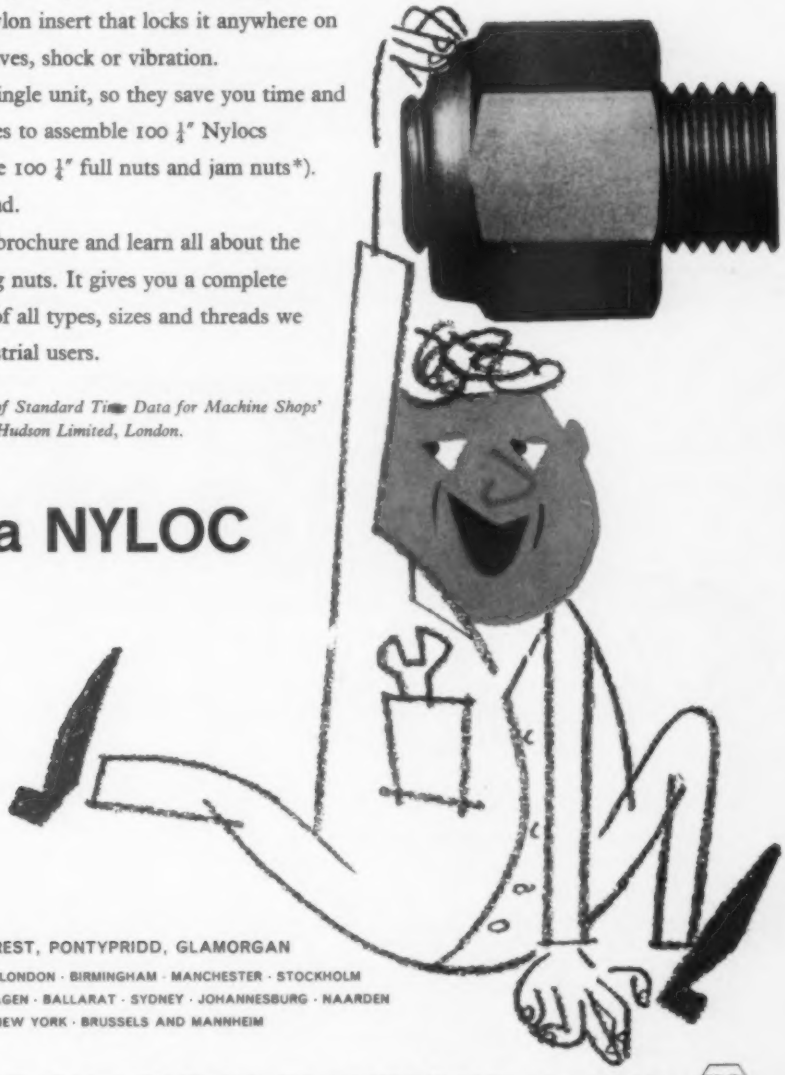

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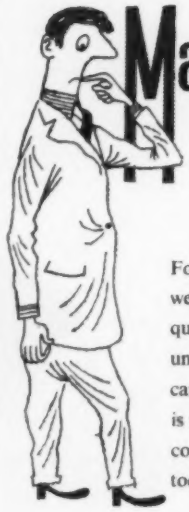

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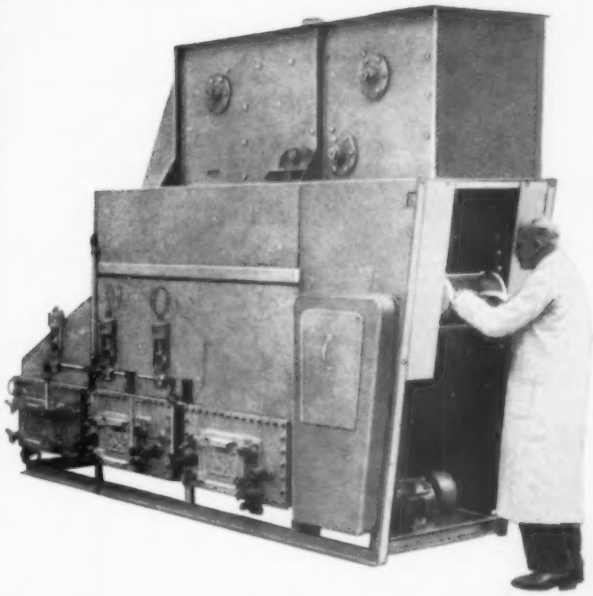

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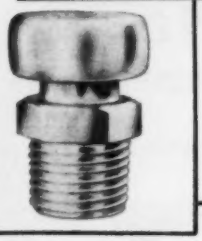

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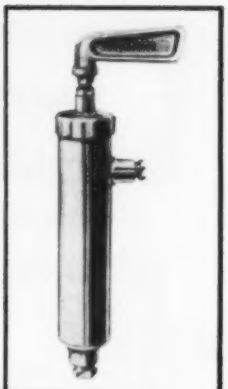

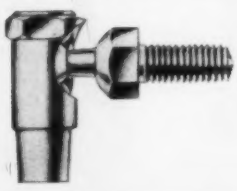

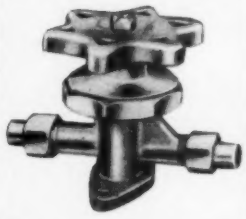

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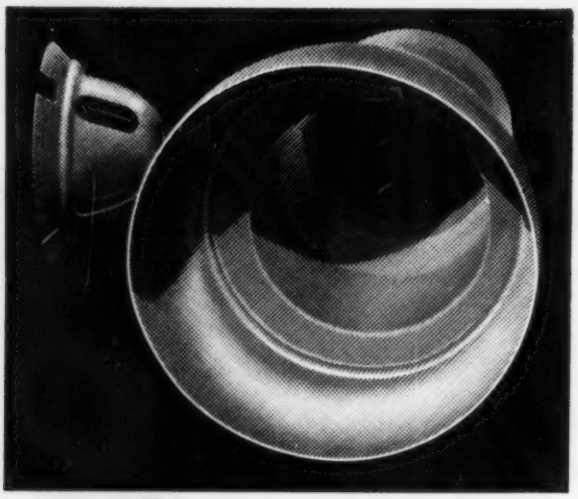

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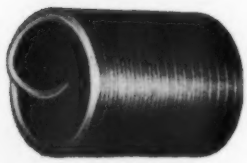

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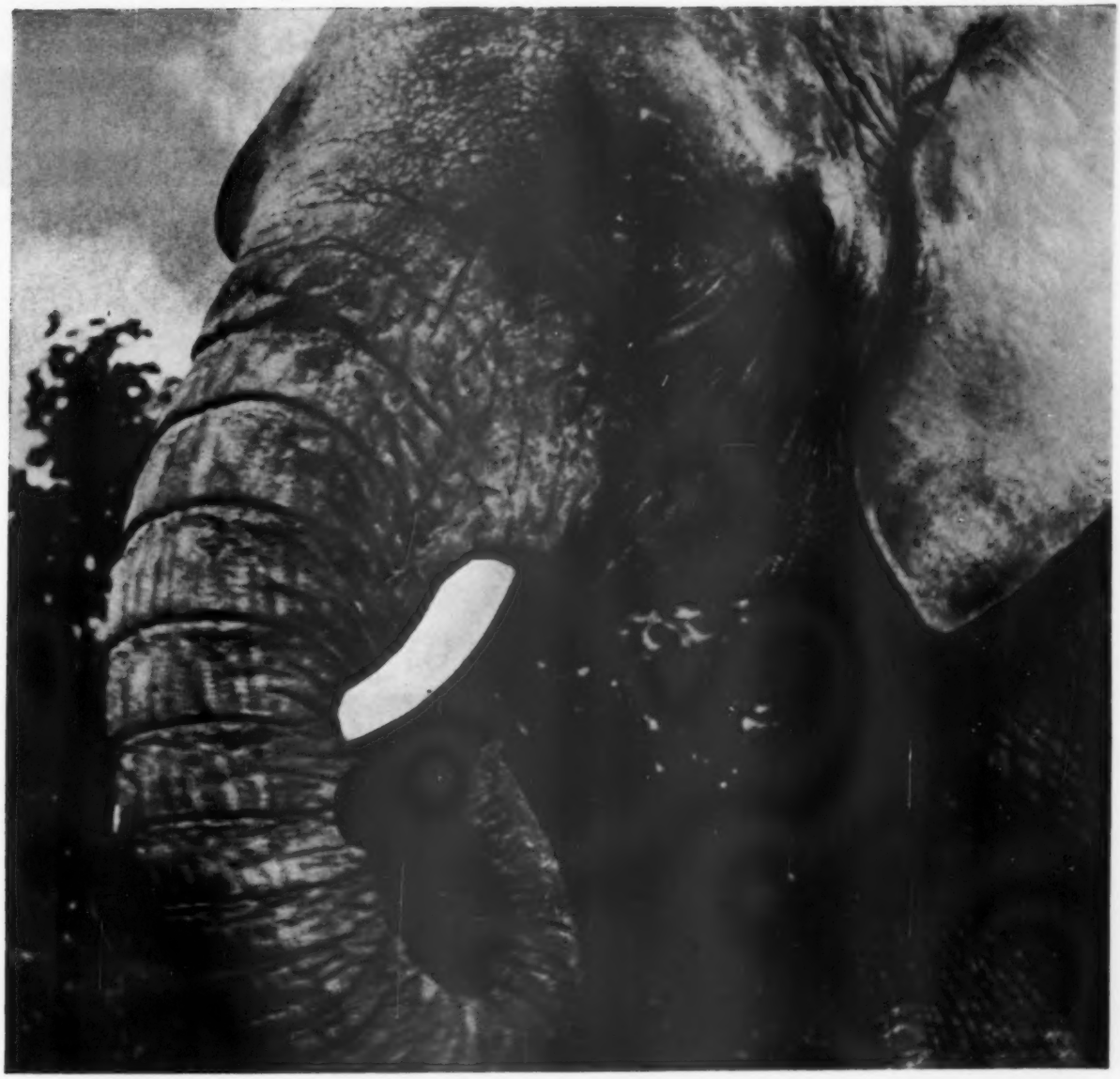

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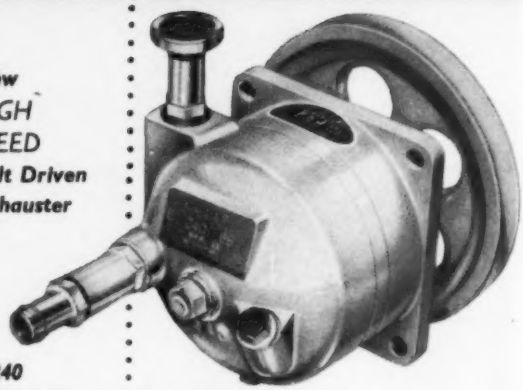

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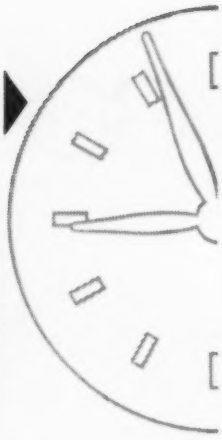

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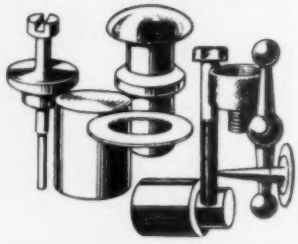

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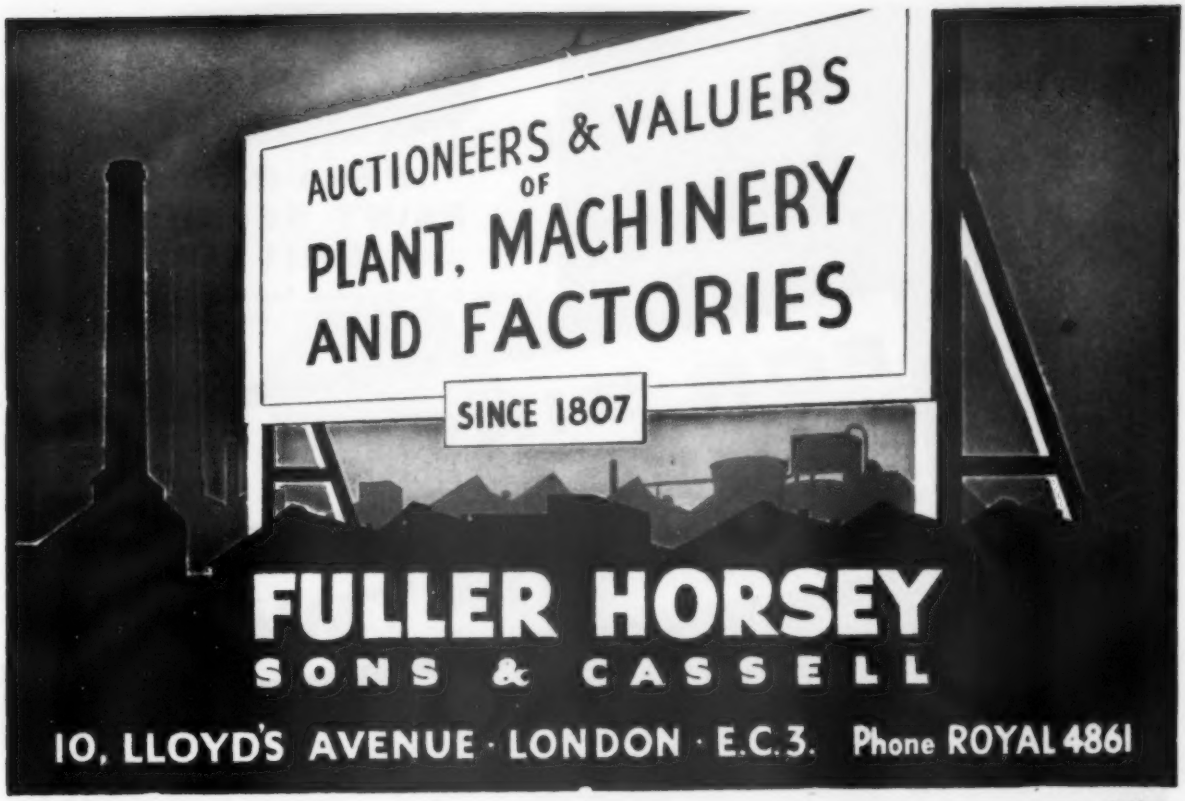

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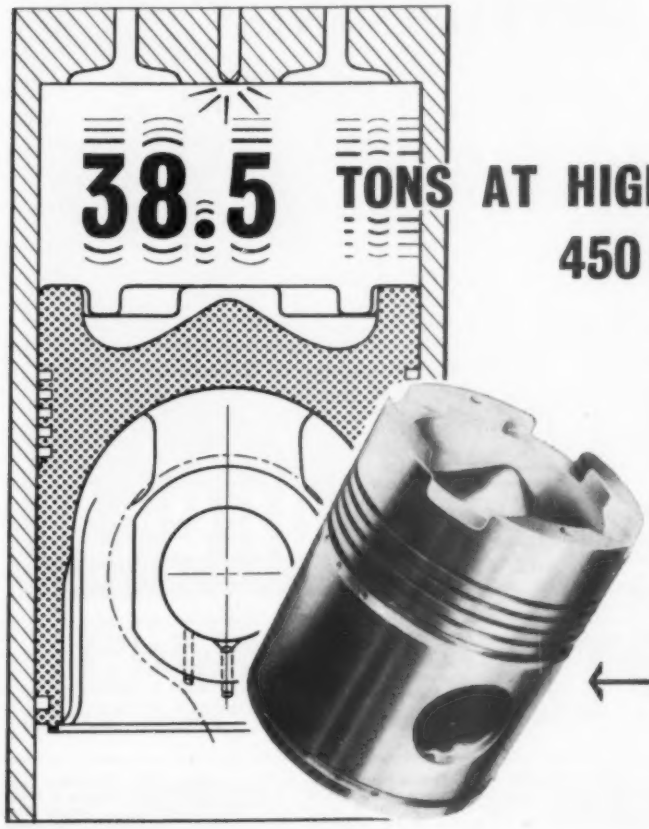

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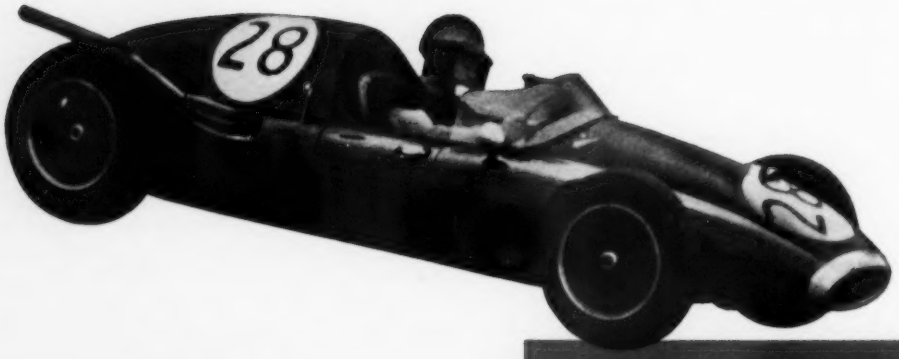

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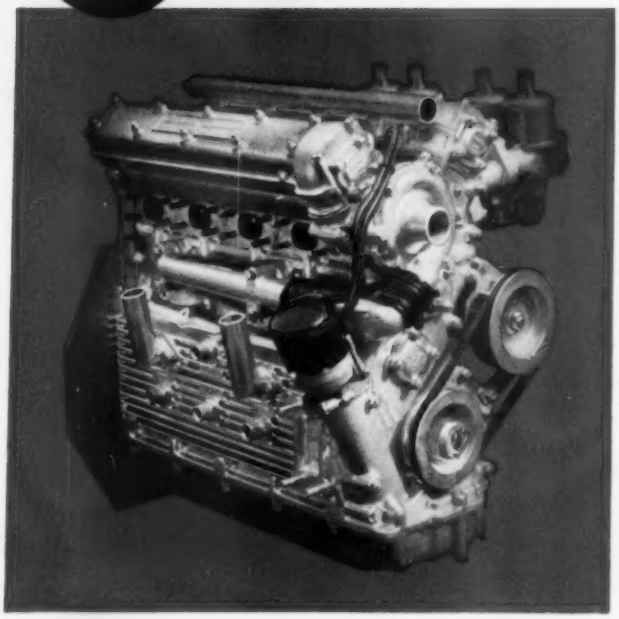

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